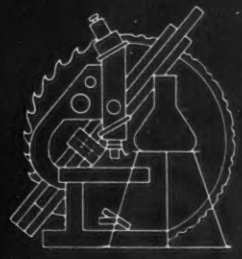
SUPPLIERS TO EXHIBIT AT ASHEVILLE—See p. 10-A

Forest Products Journal



Vol. VI, No. 2 February, 1956

Special Issue

ANNUAL REVIEW

1955 Developments in Major Segments of the Forest Products Industry

- LOGGING
- MILLING
- VENEER AND PLYWOOD
- GLUING
- PRESERVATION
- CHEMICAL UTILIZATION
- PACKAGING
- EDUCATION
- FINISHING
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World-Wide Forest Products Review

by Food and Agriculture Organization of United Nations

Plus 9 Regular Full-length Articles

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Urac 180 – General-purpose, urea-formaldehyde resin in water solution. High-solids solution (66% P.M.M.A. Method) for drum, tank-car or truck shipments. Catalysts and hardeners are available for all wood-bonding applications – cold or hot press plywood gluing, high-frequency gluing, fortification of starch-dextrine adhesives, etc.

Urac 186 – Similar to Urac 180, but containing 60% resin solids.

Urac 185 – Craze-resistant urea-formaldehyde adhesive for assembly or secondary gluing operations. Two components – liquid resin and powdered hardener. Sets at room temperature with low pressure. Excellent for bonding decorative laminates, Masonite and other hardboards.

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Urac 115 – Powdered urea resin modified to reduce clamping time in room temperature bonding of wood products without addition of highly acidic hardeners. Under special conditions, eliminates use of retaining clamps.

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Melurac 255 – Powdered melamine-urea-formaldehyde resin, two-package, formulated solely as an adhesive for tapeless splicing of veneers.

Melurac 259 – Newly developed, one-package melamine-urea-formaldehyde resin for tapeless splicing of veneers, requiring addition only of water.

Melurac 300 – Melamine-urea-formaldehyde, one-package, fast-curing colorless powdered resin for hot pressing flat or molded plywood. Combines non-staining, moderate cure temperatures, durability, boil resistance. Ideal for exterior-grade plywood. New catalysts reduce cure rate to that of hot-press urea resins.

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Melamine 421 – A powdered melamine-formaldehyde resin for use as fortifier of plaster of Paris and gypsum to increase structural strength of cast products.

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FOREST PRODUCTS JOURNAL

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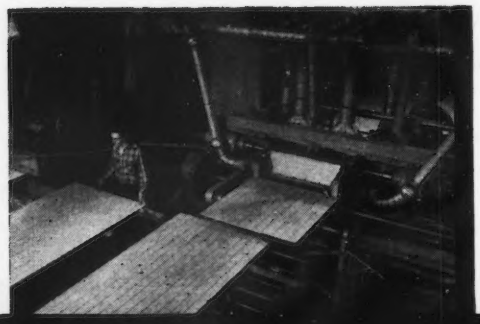

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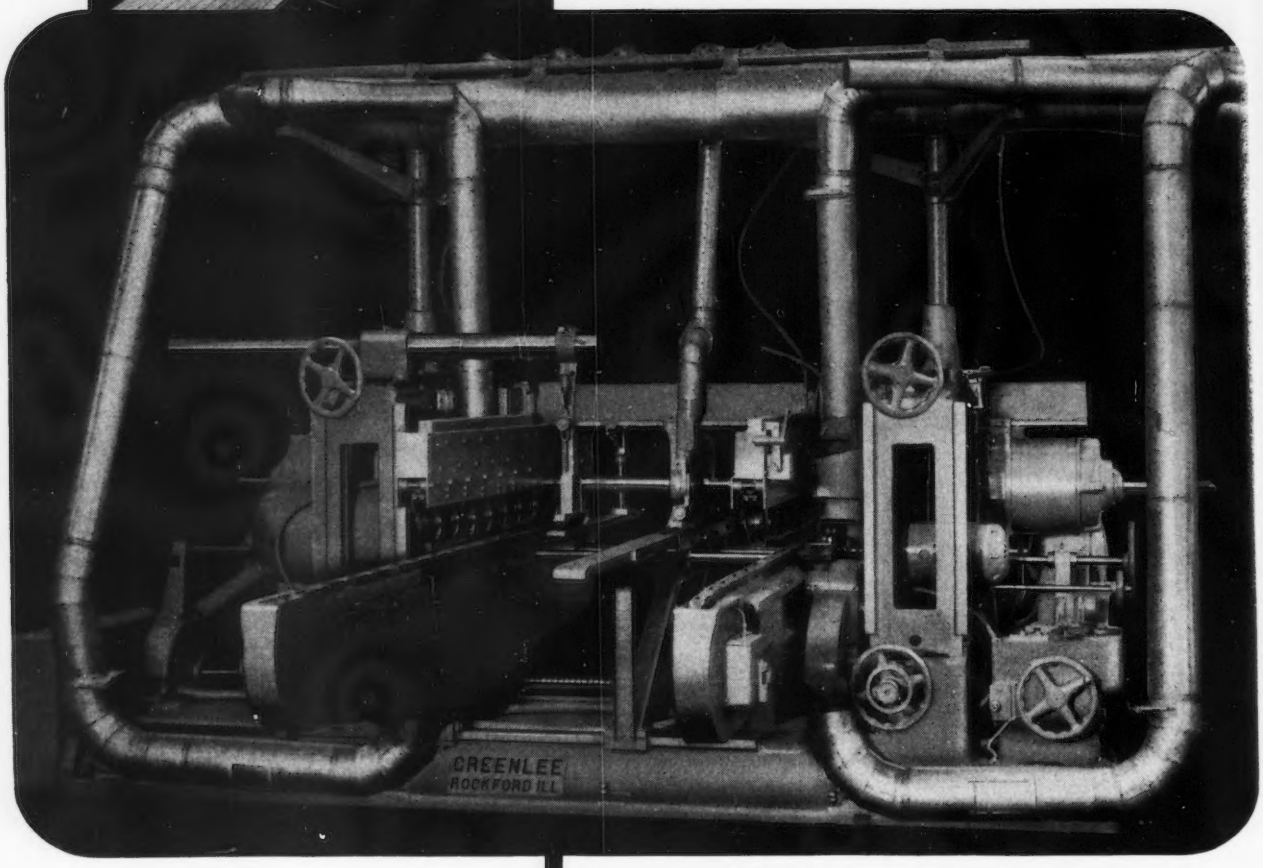
PLYWOOD SIZING AND SPLITTING



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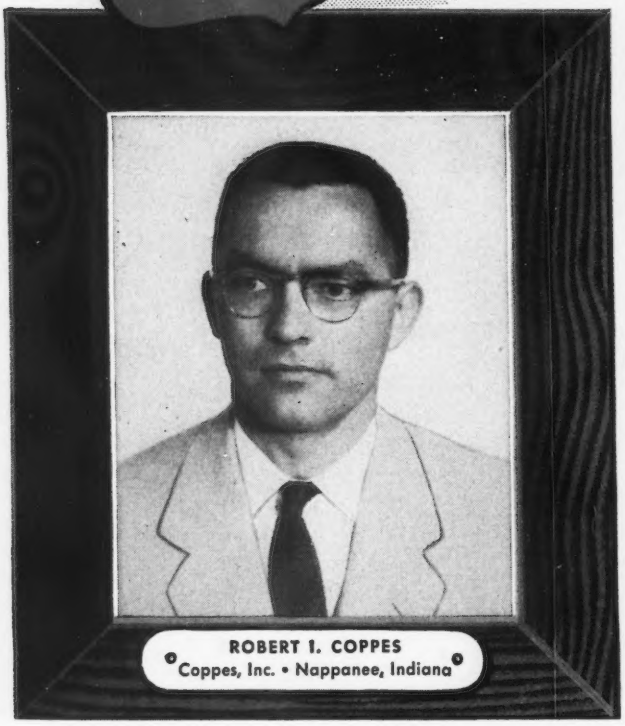


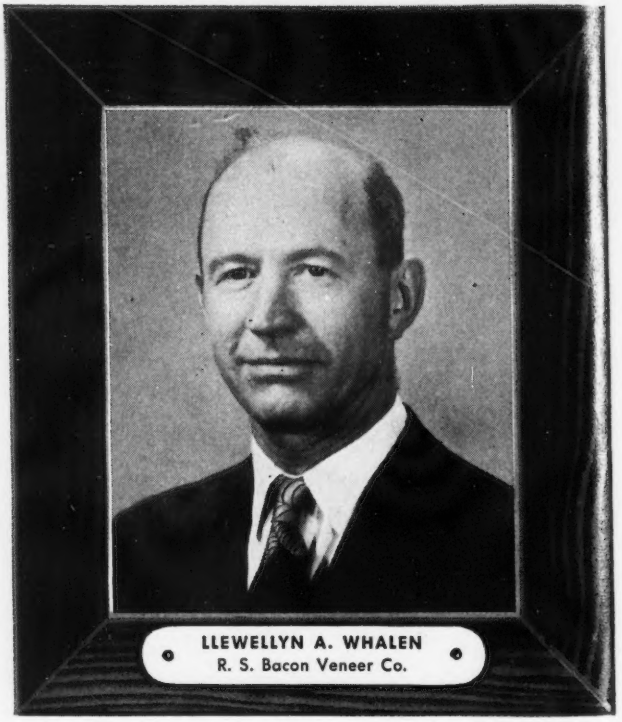
ROBERT I. COPPES
Coppes, Inc. • Nappanee, Indiana

When you think of Nappanee, you're bound to think of kitchen cabinets... when you think of "Napanee" you just naturally think of Coppes, because over the years, generations of Coppeses have spent their advertising dollars to make Coppes, Nap(p)anee, and kitchen cabinets synonymous.

Plant superintendent of this 78 year old manufacturing company, and final authority on the increasingly important subject of adhesives, is Robert I. (Bcb) Coppes, grandson of co-founder, John D. Coppes.

And, if you think the right glue is important to your adhesive jobs, just take a moment to consider the fluctuating temperatures and varying degrees of humidity kitchen furniture has to endure! Coppes builds custom hardwood kitchen cabinets to retain their beauty, sturdiness and efficiency through generations of home dwelling.

Except for five years in the army (two of these in the South Pacific) "Bob" Coppes has devoted his entire business life to protecting the Coppes heritage.



LLEWELLYN A. WHALEN
R. S. Bacon Veneer Co.

For nearly three decades—28 years to be exact—"Red" Whalen has spent most of his waking hours with wood and wood utilizations that require adhesives.

Today he is general superintendent of the R. S. Bacon Veneer Co., Chicago, manufacturers of domestic and foreign veneers and originators of "PANAWALL," the grooved panel that simulates tongue and grooved heavy planking.

Prior to his affiliation with Bacon Veneer Co., Mr. Whalen had charge of the gluing department of General Plywoods, Louisville, Kentucky;

. . . prior to that, plant manager, Plywood Products Corp., Bay City, Michigan; prior to that, quality control manager, Plywood Division, The Mengel Co., Louisville.

Married, with a daughter, 13, and a son aged 5, "Red's" hobbies are sports in general—tennis, golf and fishing in particular—reading and puttering.

Do you realize just how many really vital glue jobs there are—from laminating intricate panels for fine musical instruments to giant trusses to support a roof? Is it any wonder that we of National Casein take so seriously this job of delivering the right glue for your job—where you want it, when you want it, and how you want it—tank car, tank truck, drum or bag!

Purpose of our series on "Men Who Know Glues" *is to stimulate our own and your thinking on the subject of glues as well as to remind you that you'll stick with National Casein glues—because they stick for you.*

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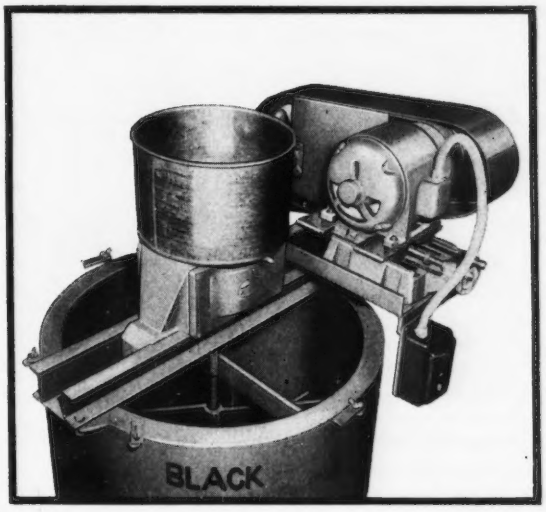

TWO-WAY AGITATION ▶

To the right is a partial view of a 60 gallon cold glue mixer arranged with a variable speed drive and water jacket. The covers have been removed showing accessibility for cleaning, and also the double agitator arrangement. Note the thick double walled tank permitting free circulation of water for cooling the glue batch.

PORTABLE MOTOR DRIVEN GLUE MIXER ▶

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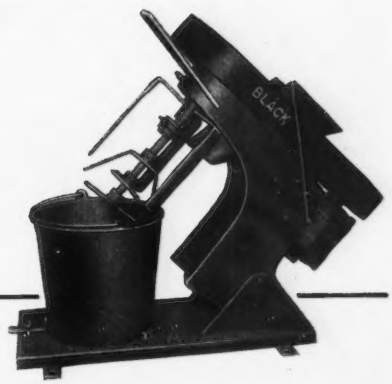

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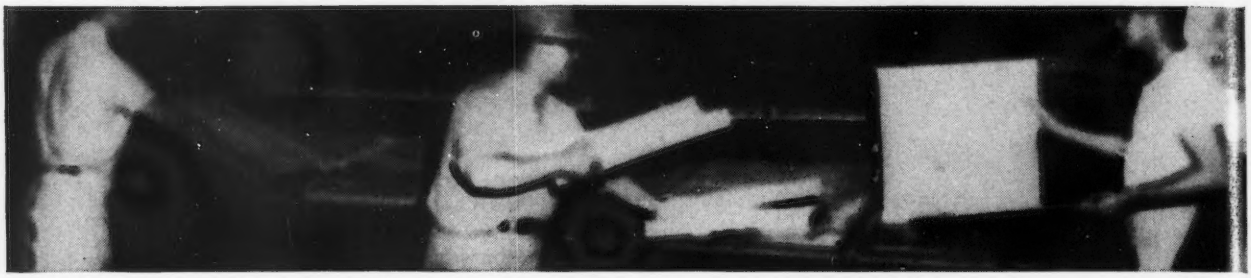

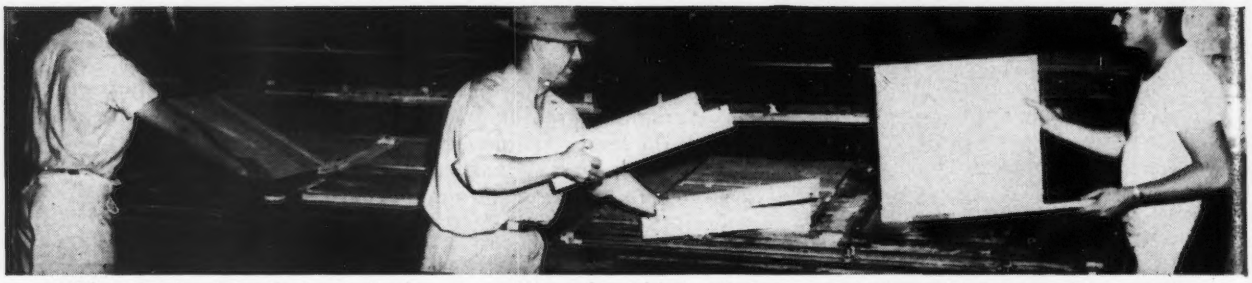

Williams Furniture Corp., Sumter, So. Carolina, uses an RCI urea-formaldehyde adhesive in a panel-to-frame high frequency gluing operation.

How RCI can focus sharply on your specific glue needs

It's easy to see why RCI is in an excellent position to fill your regular and special glue needs. To begin with, Reichhold offers a practical range of urea-formaldehyde adhesives for the furniture field . . . and phenol-formaldehyde, resorcinol, soybean and casein glues for other applications.

Viewed from the angle of quality — you can't do better. RCI glues give you the assurance of consistently high quality and dependable performance. That's because the uniformity of these adhesives is safeguarded by continued RCI quality-control — starting in many cases with the manufacture of Reichhold's own key raw materials.

Look to Reichhold, too, for fast service. RCI plants in all major sections of the U. S. can supply any firm quickly by rail tank car or highway tank wagon. And Reichhold's nationwide field service offices are ready with expert counsel.

With advantages as important as these, it's evident why Reichhold successfully serves so many furniture manufacturers year after year. If *you're* using urea-formaldehyde glues, write for Bulletins G-4 and G-6.

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1955

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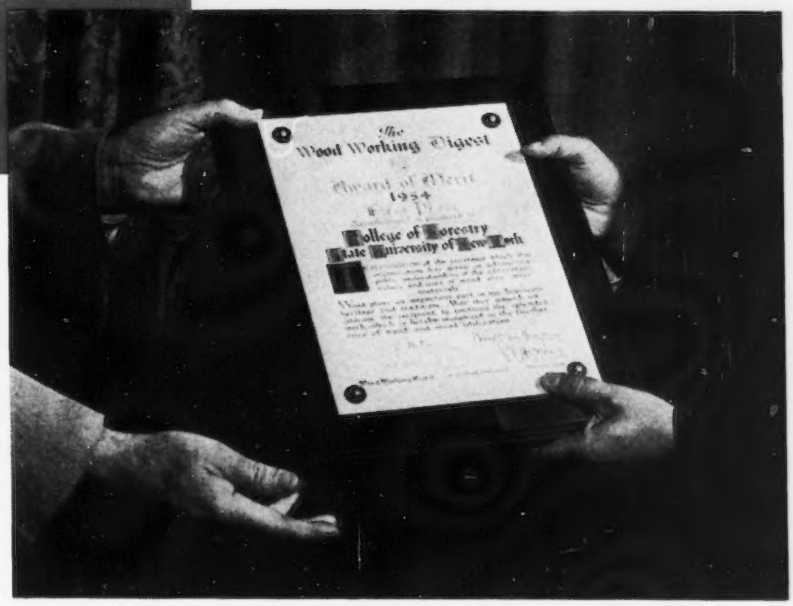

Write for official entry blank which gives full contest details.

SEND TO: The Editor, WOOD WORKING DIGEST
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Please send me an official entry blank for the Third Annual WOOD WORKING DIGEST Award of Merit Contest.

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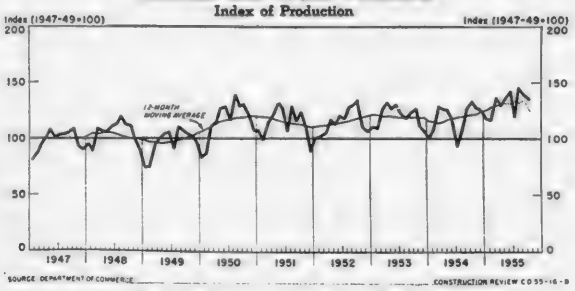
FPRS NEWS-DIGEST

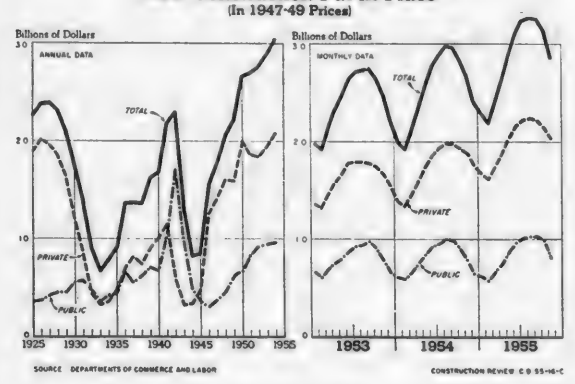
Volume VI FEBRUARY, 1956 Number 2

GRAPHIC TRENDS

Lumber and Wood Products
Index of Production



New Construction Put in Place
(In 1947-49 Prices)



1.3 MILLION HOUSING STARTS IN '56 are predicted by FHA officials, who revised previous estimate of 1.2 million. Easing of credit regulations is expected to stem the downward trend in home building. Recent decline in housing starts and seasonal decreases contributed to first drop in wholesale price index for building materials since mid-1954 recorded in November.

SECOND FASTEST GROWING INDUSTRY in nation, next to plastics, is plywood, according to Wood Working Digest. Sales since 1940 have been seven times greater than steel, production increase has topped fast-growing aluminum industry by 20% during same period. (See "Our Changing Veneer and Plywood Industry," p. 50.)

BUSINESS OUTLOOK

CHIPCORE BUSINESS BOOMING. Furniture industry has potential annual requirements for 200 million square feet of 3/4-inch core stock, 600 million square feet of 1/4-inch board, and 1 billion square feet of 1/8-inch and thinner board, it was reported at NLMA-sponsored meeting of manufacturers in February. Representatives of 16 firms established committee to consider plans for industry organization to deal with marketing, standards problems.

50% INCREASE IN RESEARCH expenditures in next decade by U. S. industry and government is predicted by Dr. Haldon A. Leedy, director of Armour Research Foundation. He estimates annual expenditure for research will reach $6 billion by 1965. Forest products industries must boost research budgets if they are to keep pace with competitive industries. Fourfold increase in research expenditures is needed now for this industry to reach 1 per cent of gross product value considered minimum essential (See Guest Editorial, page 19-A).

MANPOWER REQUIREMENTS ARE HIGH in industrial research and development, according to survey by National Science Foundation. Among 11,600 firms canvassed, 30 per cent of 554,000 engineers and scientists employed are engaged in research and development. Industry spends $3.7 billion annually for research, of which a scant $150 million goes into fundamental studies. Aircraft and electrical equipment concerns account for $1.5 billion, or 40% of gross expenditure.

—Engineers Joint Council

Suppliers Exhibit Feature of 10th National Meeting

The "FPRS Suppliers Exhibit" will be an outstanding feature of the Society's Tenth National Meeting to be held June 4–7 in Asheville, N. C. Consisting of representative displays of raw materials and equipment used in the production of wood products, the exhibit will be open daily on the ground floor of the Asheville Municipal Auditorium, meeting headquarters and location of key technical sessions. The auditorium is located in the downtown area, adjacent to the main hotels and business section.

The purpose of the exhibit is to offer an opportunity to FPRS suppliers and supporting companies to exhibit their products or services to meeting attendees in order that they may make effective contact with consumers and prospects throughout the meeting, and to stimulate a wider attendance at the meeting. It is not intended as a large-scale woodworking industry show, as was last conducted in cooperation with the Society at Grand Rapids in 1954. The exhibits will be principally of the table-top type, largely visual displays of raw materials, photographs, and light apparatus, and will not emphasize heavy machinery in operation. Light equipment that can be operated from an ordinary 110-volt outlet may be exhibited.

The 72 booths, consisting of 8-foot by 10-foot units, will occupy some 14,000 square feet of floor space. Types of exhibits will range from adhesives, finishing materials, woodworking equipment, trade publications, chipcore, and veneers, to university and research laboratory displays, finished wood products, and others. To date, about two-thirds of the exhibit space has already been allocated. Chairman of the exhibits is Dr. James S. Bethel, School of Forestry, N. C. State College, Raleigh.

In addition to the more than 600 FPRS registrants from throughout the U. S. and Canada, it is expected that an additional 400 persons from the nearby furniture and allied wood-using industries will be attracted to the meeting and exhibits. Asheville, a city of 50,000, lies within a day's travel of 60 per cent of the nation's population and is readily accessible by rail, highway, and air.

Among the companies and institutions exhibiting are: The Lilly Co.; Durez Plastics; The Dean Co.; Cleworth Publications; Perkins Glue Co.; National Casein; Miller–Hofft Co.; Dependable Machine Co.; S. H. Smith Co.; National Adhesives; Allen T. Sheppard Co.; Masonite Corp.; Reichhold Chemicals, Inc.; Hoe Co.; Power Tool Products Co.; Mall Tool Co; DeLuxe Saw & Tool Co.; Williams–Brownell, Inc.; Hardwood Corp. of America; Wilco Machine Works; Morton Salt Co.; Bramco, Inc.; Onsrud Machine Works; Kennametal, Inc.; Chipcraft, Inc.; U. S. Plywood Corp.; Simonds Saw & Tool Co.; Drexel Furniture Corp.; American–Marietta, Inc.; and Franklin Glue Co.

Asheville Municipal Auditorium, headquarters for Tenth National Meeting, will be location of FPRS Suppliers Exhibit and key technical sessions.

FPRS Suppliers Exhibit will largely consist of visual displays of raw materials and light apparatus. It will not emphasize heavy machinery in operation.

The primary attraction of the FPRS National Meeting will be the Technical Sessions and Committee Meetings. Fourteen Technical Sessions comprising some 70 papers will cover such subjects as Quality Control of Wood Products, Preservation of Wood Materials Used in Building, Prevention of Decay and Termites in Construction, Improved Plywood Products through Greater Technology, Improved Techniques for Wood Drying, What the User Wants in Composition Boards, How to Select a Better Finish for Furniture, Keeping Abreast of New Developments in Wood Gluing, Marketing — A Management Tool from Production through Retailer, Machining of Chipcore, A Growing Chemical Industry from Lignin, Hemicellulose, and Other Wood By-Products, More Complete and Profitable Utilization in Logging and Sawmilling, and Newest Methods of Packaging and Shipment of Furniture.

Some 15 Society Committees will also conduct open meetings throughout the four-day period. These will include: Quality Control, Wood Preservation, Marketing, Glues and Gluing, Veneer and Plywood, Industry-Education, Seasoning, Chemical Utilization, Logging and Sawmilling, Machining, Finishing, Composition Board, Employment, Publications, and Membership.

A wide range of entertainment for the entire family is also in store at the Tenth National Meeting. It will include the traditional "Paul Bunyan Barbecue," a family event sponsored by forest industry suppliers. They invite registrants and families as their guests to an afternoon and evening of sightseeing and pleasure at the Cherokee Indian Reservation in Great Smoky Mountains National Park, to be climaxed by an old-fashioned southern barbecue. An evening performance of "Tight Britches," an outdoor spectacle on Smoky Mountain life and times will be enacted by professional entertainers and the social program will also feature the traditional "Annual FPRS Party".

Midwest Section Plans Spring Meeting in Dubuque

Site and Program Committees have been named for the Spring Meeting of the Midwest Section, according to Chairman L. J. Fitzpatrick. The meeting will be held May 2 and 3 in Dubuque, Iowa.

Harvey Gill, Chairman of the Site Committee, will be assisted by Dwight Bensend and E. A. Patton. J. J. Allegretti is Chairman of the Program Committee and committee members are: Ted Connelly, John Reno, Harvey Gill, and Jack Koellisch.

Tentative program topics for the meeting include modular measure, consumer advertising, and material handling. The social program will include a boat ride on the Mississippi River.

Increased FPRS membership is among important objectives in 1956 set by the Section officers. Robert L. Hiller has been named Membership Chairman, to be assisted by Dwight Bensend, Jack Koellisch, Harvey Gill, John Reno, William Kluender, and Larry Fitzpatrick.

Third Wood Working Digest Award of Merit Contest Announced

June 1 is the deadline for entries in the third annual Wood Working Digest Award of Merit contest, it is announced by V. C. Hogren, Executive Vice-President, Hitchcock Publishing Co., sponsors of the awards. Entry blanks and full contest details are available from The Editor, Wood Working Digest, Wheaton, Ill.

The awards will be given to companies, schools, and associations who have done the most to promote wood and wood utilization during 1955. Each will receive a scroll, printed on German parchment, hand finished, and mounted on a solid walnut base with a recessed glass face.

Presentation of the awards will be made during the National Assoc. of Furniture Manufacturers Convention and Fair in Chicago August 27–29. Winners will be guests of Wood Working Digest during the convention. Previous awards have been presented at FPRS National Meetings but it was not possible to complete judging in time for the 1956 meeting in Asheville. It is expected that next year's awards will be presented at the FPRS National Meeting in Buffalo June 24–27, 1957.

Pacific Northwest Section Gives Student Memberships

Five University of British Columbia students have been awarded memberships in FPRS by the Pacific Northwest Section, announces H. R. Evans, Chairman. The Section also annually awards memberships to five students at U. of Washington College of Forestry and Oregon State College.

The British Columbia students are: G. K. Elliott, R. B. Gourlay, J. A. Gray, J. D. Sigalet, and Leonid Valg.

IMPORTANT FPRS DATES

Spring 1956: Mid-South Section Plant Tour to Kirby Co., Lufkin, Texas

April 19–20: Northeast Section Meeting, Springfield, Mass.

May 2–3: Midwest Section Meeting, Dubuque, Iowa

May 7–8: Pacific Northwest Section Meeting, Eugene, Ore.

June 4–7: Tenth National Meeting, Asheville, N. C.

Fall 1956: Mid-South Section Annual Meeting, Laurel, Miss.

Fall 1956: Florida–Georgia–Alabama Section Annual Meeting, Athens, Ga.

June 24–28, 1957: 11th National Meeting, Buffalo, N. Y.

Northern California Section Contributes to Building Fund

A contribution of $150 to the FPRS Building Fund, to aid in financing the proposed National Executive Office building in Madison, Wis., has been voted by the Executive Committee of the Northern California Section.

N. T. Shelton, Diamond Match Co., Chico, Calif., has been named Section Trustee, succeeding R. H. Berry, Scott Lumber Co., Burney, Calif. Berry resigned as trustee following his election as Southwest Regional Member of the National Executive Board.

The Northern California Section has also issued an invitation to the FPRS Executive Board to consider holding the 1959 National Meeting in San Francisco.

Atkinson with National Casein

In the December 1955 Journal, Fred Atkinson was listed in error as an employee of Perkins Glue Co., in a report of his election as Second Vice-Chairman, Great Lakes Section, FPRS. A former employee of the Perkins Co., Atkinson has exclusively represented National Casein Co. for the past year.

See Advance Program, Tenth National Meeting Page 15–A

April 15 Final Date for 1956 Wood Award Titles

Graduate students planning to enter the 1956 Wood and Wood Products Award competition are reminded that deadlines are April 15 for submission of tentative titles and May 1 for complete papers. Entries should be submitted to the Executive Secretary, Box 2010, University Station, Madison 5, Wis.

Five schools have indicated they may enter a total of 7 papers in the 1956 competition. They include: N. C. State College, Laval University, University of Minnesota, University of Michigan, and Yale University. Tentative titles submitted to date are: Method of Determining Drying Schedules for Veneer, and Chemical Stabilization of Wood.

The awards are open to graduate students and papers may be based on research conducted during the 1954–55 or 1955–56 school years. The first place winner will receive $350 and second place, $150, with the awards being presented at the FPRS Tenth National Meeting in Asheville, N. C. The annual awards are sponsored by Vance Publishing Corp., publishers of WOOD AND WOOD PRODUCTS magazine.

Pacific Northwest Section Sets Attendance Record

A record 221 persons registered at a meeting of the Pacific Northwest Section Feb. 6–7 in Longview, Wash. Six new FPRS members were enrolled during the meeting.

The program opened with a tour of Tollycraft Corp., where the group saw construction of pleasure boats using scarfed marine plywood, glass cloth, and other materials. During a tour of Long–Bell Lumber Co., registrants viewed a new type of veneer drier-feeder, the manufacture of pressed wood boards at the new panelboard plant, and manufacture of fir and birch-faced kitchen cabinets.

Section Chairman Harold R. Evans, director of Plywood Research Foundation, was principal banquet speaker. He described his observations of forest products industries in Europe during a recent extensive tour.

Subjects discussed during two technical sessions were: steaming veneer blocks, grading green, rotary cut western softwoods, identification of exterior plywood, effect of dryer temperature upon gluing properties of Douglas-fir veneers, dimensional stability of commercial hardboard, relationship of wood composition board to plywood, future use of overlaid Douglas-fir plywood, and various treatments of plywood.

INDUSTRY NEWS

California Studies Utilization, Names Advisory Group

The California timber industry must find more and better uses for wood, Henry J. Vaux and Fred E. Dickinson told foresters recently. Vaux, dean of the U. of California School of Forestry, and Dickinson, director of the School's Forest Products Laboratory, addressed forestry teachers at a conference on the Berkeley campus.

"The problem of diminishing stands and high production costs must be tackled from the efficiency angle," Vaux said. "California had 395 million cubic feet of residues in 1952, twice as high as the rest of the nation. The cost of handling these residues is so high they now must be left at the mill or in the woods," he added.

In a talk before graduates of the School of Forestry, Dickinson described the part the new Forest Products Laboratory will play in increasing utilization of the forest crop. The Laboratory will have two divisions working on utilization problems, he said, one in forest products chemistry and the other in timber physics and mechanics. The latter will study means of utilizing residues.

Appointment of a Technical Advisory Council for the Laboratory has also been announced by Dickinson. The group, which consists of 12 executives of California wood industry firms, will advise the Laboratory of the industry's research needs.

Council chairman is Earl B. Birmingham, FPRS member and president of Hammond Lumber Company, San Francisco. Other FPRS members serving on the council are: A. T. Hildman, Lee Moffett, R. A. Colgan, Jr., Theodore C. Combs, Edward Feldman, William G. Van Beckum, and Charles Berolzheimer.

Northwest Wood Products Clinic Schedules Annual Meeting

The eleventh annual meeting of the Northwest Wood Products Clinic will be held April 10 and 11 at the Davenport Hotel, Spokane, Wash. Program details may be obtained from Everett Ellis, Secretary-Treasurer, Box 291, Univ. Station, Moscow, Idaho.

Plant Capacity Doubled

Increased demand for vinyl acetate resin has necessitated doubling the capacity of the Meredosia, Ill., plant of National Starch Products, according to Frank Greenwall, president. The Meredosia plant, which went into production in August, manufactures polyvinyl acetate emulsion, vinyl acetate copolymers, and adhesives made from vinyl acetate resin.

Northeastern Loggers Congress Will Feature Sawmill Clinic

A sawmill clinic will be a special feature of the Second Northeastern Loggers Congress to be held April 25 and 26 in Woodstock, Vt. Prof. K. C. Compton, State University of New York College of Forestry, is arranging the session, which will include talks by F. B. Malcolm, U. S. Forest Products Laboratory, and Milton H. Mater, Mater Machine Works, Corvallis, Ore.

Three sessions will deal with cost control in logging, new methods and machinery, and advantages and disadvantages of tree-length logging. Further information on the Congress may be obtained from Frank A. Reed, treasurer, Old Forge, N. Y.

Beil Heads Curtis Research and Development Department

A separate product research and development department has been established by Curtis Companies, Inc., under a new plan of executive organization announced by President George M. Curtis. The firm, which has plants in Iowa, Wisconsin, Minnesota, Illinois, Nebraska, Kansas, and Pennsylvania, has introduced many new and improved millwork products. Even greater emphasis will be placed in the future on the development of new products, Curtis said.

Forrest F. Beil, associated with the firm since 1917, heads the new department. He is the designated representative to FPRS of the firm, a company supporting member. A past chairman of the Midwest Section, Beil has served on Society committees and contributed to many FPRS meetings.

Firm Name Changed

The name of Snyder Chemical Corp., Bethel, Conn., has been changed to Synco Resins, Inc.

SHORT COURSES

Hardwood Lumber Grading Course Scheduled at Syracuse College

Floyd T. Potter, field inspector for the Northeastern District, National Hardwood Lumber Assoc., will be in charge of instruction at the annual hardwood lumber grading course to be given April 2 to 6 at State University of New York College of Forestry, Syracuse.

The course will include discussion of the NHLA Rules Book and actual practice in grading mixed hardwoods. Allied subjects to be covered include: growth and structure of wood, natural defects, seasoning defects, and other factors influencing lumber grade.

Applications should be sent to Hardwood Lumber Grading Short Course, Forest Utilization Dept., State U. College of Forestry, Syracuse 10, N. Y.

NAMES IN THE NEWS

Ira Hatfield Named Research Director of Chemical Firm

I. HATFIELD

Ira Hatfield has been appointed Director of Research at Wood Treating Chemicals Co., St. Louis, Mo., national sales agent for Monsanto pentachlorophenol. He was formerly manager, industrial preservatives section, Monsanto Chemical Co.

Chairman of the FPRS Wood Preservation Committee, Hatfield is credited with the discovery of the value of pentachlorophenol as a wood preservative and has been associated with its development for the past 20 years. From 1929–36, he was employed in preservation research by the U. S. Dept. of Agriculture at the Forest Products Laboratory and Southern Forest Experiment Station. He joined Monsanto Chemical Co. in 1936 and has since worked in the organic chemicals section, except for two years when he was co-owner of a chemical company.

B. V. SCHAUB

R. M. MILLER

B. V. Schaub has been elected president of the Canadian Packaging Association. He is vice-president and director of National Adhesives, (Canada), Ltd.

Appointment of **Robert M. Miller** as sales manager, Woodworking Machinery and Portable Tool Divisions, has been announced by Onsrud Machine Works, Inc., Chicago. Miller was formerly associated with John Oster Manufacturing Co.

Robert C. Fraunberger recently joined Lumbermens Merchandising Corp., Philadelphia, as vice-president and general manager.

Milton E. Ryberg is with the U. S. Naval Supply Research and Development Facility, Naval Supply Depot, Bayonne, New Jersey, heading the Food Preservation Section.

Raymond L. Mitchell, research chemist at the U. S. Forest Products Lab, Madison, Wis., for 26 years, died in December after a long illness.

The BEST *FINISHING* PLANER is one that does the best job of *PRELIMINARY PLANING, TOO!*

No. 44 Single Surface, 4 roll planer for first cutting and finishing work.

ONE BASIC REASON FOR THIS is that the strategically located extra weight and strength which permits a planer to do an outstanding job of preliminary planing, with its greater strains and stresses, also provides the added stability so necessary to obtaining the finest finish planing.

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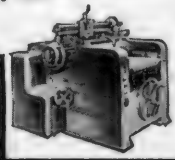
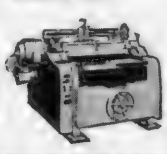
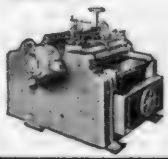


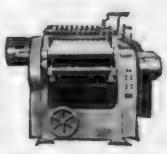
No. 66 Single Surface, 6 roll planer for first cutting and finishing work.



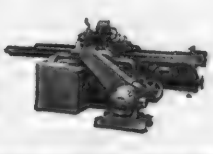
No. 88 Double Surface, 8 roll planer for first cutting and finishing work.



No. 55 Heavy duty Double Surfacer for planing rough lumber.



MICRO-SURFACER for planing hardboard and other very thin materials.



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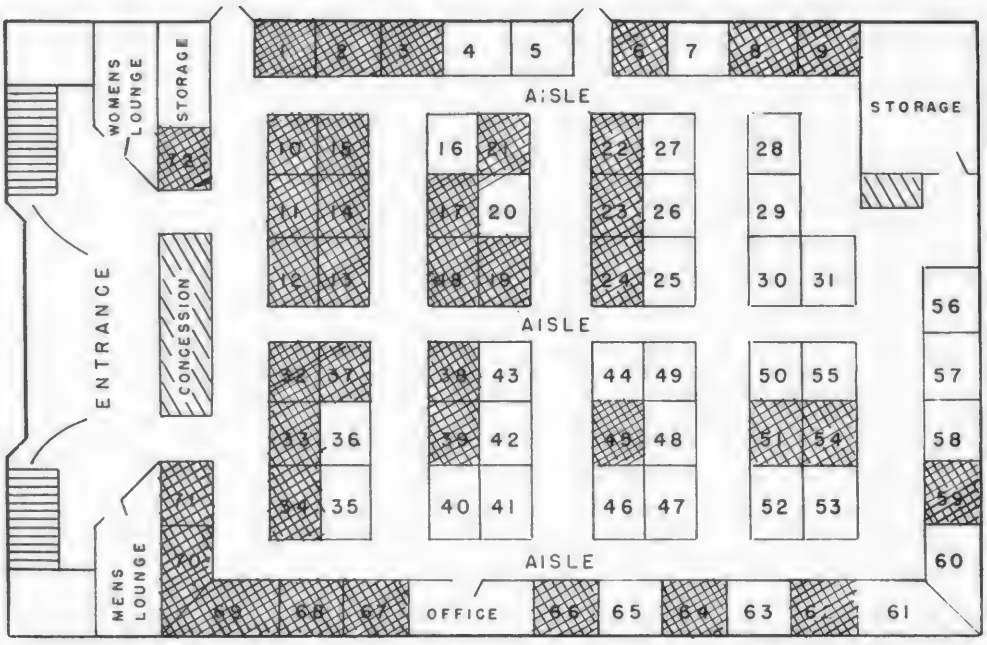
FPRS 10TH ANNUAL MEETING AND SUPPLIERS EXHIBIT, MUNICIPAL AUDITORIUM, ASHEVILLE, N. C., JUNE 4–7



Note: Shaded areas indicate booth spaces assigned as of Feb. 15

ONE SIZE: 8 by 10 foot

ONE PRICE: $100!

(MULTIPLE SPACES AVAILABLE)

THE Forest Products Research Society cordially invites suppliers to the wood industry to participate in the combination Booth and Table-Top Exhibit to be held in conjunction with FPRS 10th National Meeting June 4–7 in Asheville, N. C.

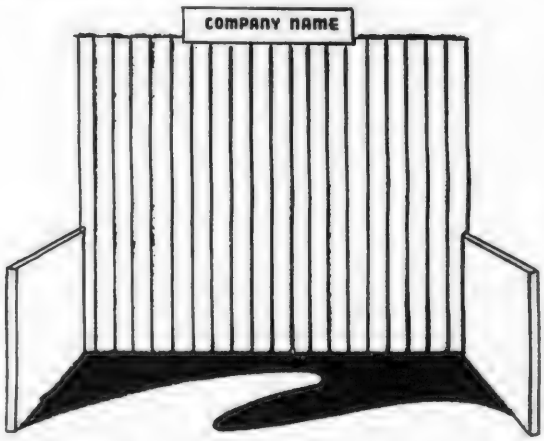
As of March 1, more than 50 of 72 available spaces have been reserved. The balance of space will not last long and prospective exhibitors are advised to act immediately. (See p. 10–A for list of exhibitors to date.)

Important Notice: This Exhibit is **not** to be confused with the so-called "Heavy Machinery" type, full-scale Industry Show as was last held in cooperation with FPRS in 1954 at Grand Rapids. The exhibit will **not** feature large, operating machinery. However, types of machinery and equipment that can be demonstrated or operated from 110-volt current may be displayed.

The exhibit will stress a variety of raw materials, adhesives, chipcore processes, laboratory facilities, light equipment, moisture registers, kiln equipment, furniture finishing processes, and similar services.

Total attendance for the 4 days will be on the order of 600 regular registrants plus 400 specially invited personnel from Southeast woodworking industries, principally furniture manufacturing.

The Exhibit will be open from 10:00 a.m. to 4:30 p.m. daily.



Sketch of standard 8-foot deep by 10-foot wide booth including backwall and side dividers. Price of $100 per booth includes table, two chairs, company sign, and exhibit program listing at no extra cost.

Note: All space will be allotted on a "first come—first served" basis. Be sure to indicate your first, second, and third choices for space.

Address all communications in regard to booth space to:

Dr. James S. Bethel
School of Forestry
North Carolina State College
Raleigh, North Carolina

Advance Technical Program, 10th National Meeting

Monday, June 4

Session I—Quality Control in Wood Products. C. S. Latimer, Chairman. 1. Application of Linear Programming to Plywood Industry, J. S. Bethel, N. C. State College; 2. Experimental Designs Applicable to Problems of Wood, R. J. Hader, N. C. State College; 3. Quality Problems in Athletic Goods Manufacturing, J. Saunders, A. G. Spalding & Bros.; 4. Management Possibilities with Quality Control Methods, C. A. Bicking, Office of Chief of Ordnance; 5. Acceptance Sampling of Veneer Using Lot-Plot Plan, A. E. Wylie, New York College of Forestry, and W. C. Hitchings, W. Quincy, Mass.; 6. Statistical Sampling Proved to be Efficient and Accurate in Receiving Inspection.

Session II—Preservation of Wood Materials Used in Building. Ira Hatfield, Chairman; C. S. Walters, Presiding. 1. How to Prevent Fungus Damage to Wood Structure, A. F. Verrall, U. S. Dept. of Agriculture, Gulfport, Miss.; 2. How to Prevent Insect Damage to Wood Structures, R. J. Kowal, Southeastern For. Exp. Sta.; 3. Use of Preservatives in Board Products, W. L. Meek, Minnesota & Ontario Paper Co., International Falls, Minn.; 4. How and What to Specify for Preservative Treatment of Wood to be Used in Buildings, R. B. Putman, Koppers Co., Pittsburgh, Pa.; 5. Marketing Preservative Treated Wood Products, W. J. Butler, Dierks Forests Inc., Kansas City, Mo.; 6. New Method for Long Term Preservation of Wood by Chemical Modification, E. Abrams, F. G. W. Smith, S. Miller and R. R. Bottoms; 7. New Method for Applying Pentachlorophenol to Wood in Place, R. G. Van Allen, Wood-Treating Chemicals Co.; 8. Oscillating Pressure Method of Preservative Treatment, M. S. Hudson.

Session III—Prevention of Decay and Termites in Building Construction. Ira Hatfield, Chairman; R. M. Lindgren, Presiding. 1. Prevention of Decay and Termites in Building Construction, by an architect; 2. Paper by contractor; 3. Can Wood be Used Successfully and Economically in Home Building Today and Will It Perform as Well as Competitive Products? W. H. Scales, Representative, NLMA, New Orleans; 4. Paper by termite control operator; 5. Paper by supplier of treated wood.

Session IV—Marketing—A Management Tool from Production through Retailer. P. H. W. Creden, Chairman. Authors will include: L. J. Carr, L. J. Carr & Co., and J. R. Welsh, Welsh Plywood Co.

Session V—Keeping Abreast in Wood Gluing. A. A. Marra, Chairman; D. B. Richards, Program; J. S. Bethel, Presiding. 1. Recent Developments in Fast-Setting Adhesives; 2. Gluing Overlays to Wood Products; 3. Performance of Urea Resin Glues at Elevated Temperatures, R. F. Blomquist and W. Z. Olson, U. S. Forest Products Lab.; 4. Fast Hot Pressing with Cold-Setting Glues; 5. Maintaining Glue Bond Quality in a Furniture Plant; 6. Factors Affecting the Performance of Wood Adhesives in Thick Glue Lines (by title only), the late E. Hinken.

Tuesday, June 5

Session VI—Keeping Abreast in Wood Gluing. A. A. Marra, Chairman; D. B. Richards, Program. 1. Production and Quality Control of Laminated Timbers, M. Rhude, Unit Structures, Inc.; 2. Production Gluing of Blumenstein, W. Finnorn, A. Rapavi; ing Radii for Curved Laminates, R. Blumenstein, Timber Engineering Co.; 4. Production Laminating of 2 x 4's, H. McKean, Potlatch Forests, Inc.; 5. How Long Will It Last?—A Study of Glue Line Durability.

Session VII—Improved Techniques for Wood Drying. L. D. Espenas, Chairman; W. R. Smith, Presiding. 1. Factors to Consider Concerning the Thickness of Stickers for Dry Kiln Loads, F. W. Cook, Moore Dry Kiln Co.; 2. Predicting the Uniformity of Moisture Content in Drying Lumber, W. E. Pratt, California Redwood Assoc.

Session VIII—Chemicals from Lignin, Hemicellulose and Other By-Products. R. C. Sproull, Chairman; E. G. Locke, Presiding. 1. Whole Tree Harvesting — Pulp and Paper from Different Sections of Pine Trees, R. C. Sproull; 2. Separation and Utilization of Hemicelluloses, J. F. Saeman, J. F. Harris and E. G. Locke, U. S. Forest Products Lab.; 3. Effect of Swelling Agents and Catalysts on Esterification of Wood, F. Bender and L. P. Clermont, Forest Products Laboratories of Canada; 4. Nature of Aspen Lignin, I. A. Pearl, Inst. of Paper Chemistry.

Wednesday, June 6

Session IX—Machining of Composition Board. L. A. Patronsky, Chairman. 1. Sanding Particle Board to Thickness, D. Haile, Rock Island Millwork Co.

Session X—More Complete Utilization in Logging and Milling. F. C. Simmons, Chairman; E. L. Demmon, Presiding. 1. Chip Yield by Log Grade and Size in the California Pine and Fir Region, T. Shelton, Diamond Match Co.; 2. Position of Wood Chippers in Wastewood Utilization, R. H. Alexander, Howard Smith Paper Mills, Cornwall, Ontario; 3. Sawmill Waste Utilization, E. P. Ivory, Ivory Pine Co.; 4. Future of Rubber-Tired Tractors in Logging, W. McGraw, Caterpillar Tractor Co., Peoria, Ill.; 5. Damage to Residual Stands as a Result of Logging Operations, D. P. Herrick, Central States For. Exp. Sta.; 6. Genetical Aspects of Specific Gravity, B. Zobel; 7. Development of an Automatic Sawmill Carriage Feed, M. H. Mater, Corvallis, Ore.

Thursday, June 7

Session XI—What the User Wants. G. G. Marra, Chairman. 1. Use of Composition Boards in Mass Home Building; 2. Composition Boards in Displays and Store Fixtures; 3. Composition Boards in Radio, TV, and Sewing Machine Cabinets; 4. Furniture Manufacturing Comes of Age with Composition Boards; 5. Insulation Roof Decking—A New Structural Material; 6. Composition Boards in the Seating Field.

Session XII—How to Select a Better Finish for Furniture. E. S. Johnson, Chairman. 1. Selecting Decorative Laminates or Plastic Overlays, A. J. Kirsch, American Cyanamid Co.; 2. Discoloration of Furniture Finishes, D. Lubeck, Hammond Organ Co.; 3. Evaluating Cold Check Resistance of Furniture Finishes, R. M. Carter, and Mr. Schrumpf, N. C. State College; 4. Synthetics vs. Nitro-Cellulose Lacquers; 5. Infra Red Drying.

Session XIII—Packaging and Shipment of Furniture. K. W. Kruger, Chairman; F. Weber, Presiding. 1. Cushioning Materials for the Protection of Furniture, J. Hoffman, Kimberly-Clark Corp.; 2. Packaging and Shipment of Furniture by Rail Shipment, J. C. Anderson, Southern Weighing and Inspection Bureau; 3. Packaging of Furniture for Truck Shipment; 4. Fiberboard Furniture Packages; 5. Protecting Furniture for Shipment, S. W. Freeman, Drexel Furniture Co.

Session XIV—Improved Plywood Products through Technology. H. O. Fleischer, Chairman; D. Nichols, Presiding. 1. Knives and knife maintenance in the veneer industry, N. Bowditch, Simonds Saw and Steel Co.; 2. Engineering Design of a Veneer and Plywood Plant, E. H. Merritt, Lockport, N. Y.; 3. Maintenance of Quality in the Veneer and Plywood Manufacturing Process, R. A. McKay; 4. Trends in Veneer and Plywood Production, C. M. Wildes, Bureau of Census.

Thermatron bonded panels 120" x 10" come from the press at Bally Block Co. in three minutes—yet the old method required at least three hours just for the glue to set. Then each hand clamp had to be loosened to remove the panels. Incidentally, the space needed to handle the seven short panels shown in the bottom picture is just about the space taken up by the new Thermatron electronic equipment which gives many times more production.

Edge Bonding at Bally Block Co. now a fast, streamlined operation with THERMATRON electronic equipment

Bally Block Co., Bally, Pa., required volume production of edge bonded panels—which they get now with their powerful new 20 KW Thermatron radio frequency generator and hydraulic press installation.

The equipment easily accommodates stock 6 inches thick and 8 feet long, while longer panels are handled progressively. Once fed into the press, they receive an electronic "jolt" and the bond becomes stronger than the wood itself.

There's an extra, too. Bally Block found that large storage areas once given over to glue drying are now released for production instead. This gives them far more payload per factory foot.

Let us show you without obligation how modern methods can speed *your* wood bonding operation and achieve vast savings. Thermatron equipment is available up to 300 KW in all degrees of automation to suit your special purpose. Please request a copy of our latest bulletin

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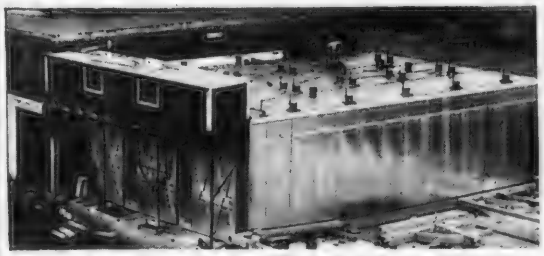
We goofed...

and we *certainly* want to rectify our error. In a recent ad, we incorrectly captioned this photo "the *U.S.S. Enterprise* with the *Queen Mary* in the background." Actually, it's the *U.S.S. Forrestal* with the *S.S. United States* in the background. Our only excuse is that we're dry kiln experts . . . and obviously not too hep on ships! We hope all of you who called the error to our attention will forgive our "ship ignorance".



Here's the STANDARD PREFABRICATED DRY KILN installation at the Newport News Shipbuilding & Dry Dock Company, builders of both the *U.S.S. Enterprise* and the *U.S.S. Forrestal*! Read what this firm says about STANDARD prefab kilns in a specially-prepared booklet. Write for your FREE copy.

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Needed: Students for Summer Jobs

GREETINGS, FELLOW MEMBERS. It is good to be writing you again. By the way, how do you like our new *monthly* JOURNAL. I believe it is another sign of FPRS' progress and in the long run will mean more editorial material delivered in more timely fashion.

Last month, I emphasized our Summer, 1956, Student Employment Program under the direction of Dr. Newell A. Norton, Penn State University. I stressed the need for individual companies to offer summer training jobs for students now in our wood technology schools, and said that in so doing you might well be appraising the young men who can mean the success of your business in future years.

M. B. Christian

Since then I have been able to witness more evidence of the work of the FPRS Employment Committee and I am now more than ever convinced that we are on the right track with this program. It is only a question of time and further refinement of the procedure before FPRS may truly be one of, if not the most important, connecting links between promising young men in our colleges and you as potential employers. One step is through seasonal on-the-job training.

Response to the Committee's work has been both productive and enlightening. Where many of us felt the biggest push would be needed in soliciting companies to provide sufficient summer jobs to meet the needs of our colleges, actually the shoe is on the other foot! Companies have been faster to respond with jobs than have our forest products technology schools to respond with lists of students available for summer employment!

For example, some 65 firms (27 North–Central, 26 Northwest, 10 Northeast and 2 South–Central) have come forward. On the other hand, of some 42 colleges invited to participate, we have had acknowledgments or participation by only 17. Some of our leading schools have not responded. What is the reason? We must assume that many of the faculty members are already too overburdened with other responsibilities to become additionally involved in this program; or that they already have an effective program of student summer employment placement; or simply that the times are such that students require little assistance in obtaining summer employment. The fact remains, however, that we may not always have an economy of full employment, and that now is the time to sow back a part of our harvest so that we may be assured of a richer tomorrow.

As stated, we have made a splendid start so far this year. It remains now to see how many of our wood technology students will contact these 65 firms this Spring, and what their eventual experience will be. Our task has only begun, however, and if you, whether school or industry, have not yet indicated your interest in the program, I urge you to do so without delay. We still need more job opportunities and more students to fill them this summer if our segment of the forest products industry is going to successfully make a start in competing for talent against its more experienced and larger counterparts in competitive industries. Dr. Newell A. Norton, School of Forestry, Penn State University, University Park, Pa., and/or the Executive Office, Box 2010, University Station, Madison, Wis. will welcome your participation or comments.

MOSS B. CHRISTIAN, *President*

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FPRS Committees—Contributors to Society's and Industry's Growth

FRANK H. KAUFERT

Vice-President, FPRS, and Director, School of Forestry, University of Minnesota

I WISH TO TAKE THIS OPPORTUNITY on behalf of all officers and members of the Forest Products Research Society to salute and congratulate our Subject Matter or Technical Committees for the outstanding work they have done and are doing in furthering the program of the Forest Products Research Society and in benefitting the entire forest products industry.

It was not until you gave me the responsibility of coordinating the activities of our 13 Subject Matter Committees: Wood Preservation, Industry–Education, Wood Machining and Equipment, Logging and Milling, Wood Finishing, Packaging, Wood Composition Board, Veneer and Plywood, Marketing, Wood Drying, Glues and Gluing, Quality Control, Chemical Utilization, and the special Employment Committee that I gained real appreciation for the importance of these committees to our Society and to our industry. Every member of these committees has made an important contribution to the function, growth, and development of our Society. Committee Chairmen have made an especially important contribution and FPRS members and the forest products industry owe them a particular vote of thanks and expression of appreciation for the time and attention they have given to their assignments.

Many Responsibilities

Committee Chairmen, other Committee officers, and individual Committee members had the responsibility for preparing reports on their Seattle meetings, which were included in the October, 1955, FOREST PRODUCTS JOURNAL. Ever since the Seattle meeting, Committee Chairmen and Committee members have been working with President–Elect Ralph H. Bescher in the development of technical session programs for the Tenth National Meeting. Although only a part of the correspondence relating to the development of these technical session programs has come to my attention, this has been sufficient to indicate the volume of work involved and the excellence of the program which will be presented to you at Asheville.

Committee Chairmen and their Committees have also been responsible for the reports in this month's Annual Review Issue of the FOREST PRODUCTS JOURNAL. These reviews should be particularly appreciated by Society members and the many others in the forest products industry who will read them because they present in brief summary fashion some of the important highlights and developments in the areas covered.

Committee Chairmen have also been active in planning for Committee meetings at Asheville, during which they will discuss past activities, organization and reorganization of their committees, and program plans for the 1957 Buffalo meeting. That our Committees have been active and busy is indicated by their abundant accomplishments and their plans for the future.

Not only is a vote of thanks and an expression of appreciation to Committee Chairmen and Committee members due from Society members but from the entire forest products industry. A large part of the forest products industry and its owners and management is increasingly aware of the important job the Forest Products Research Society is doing in promoting research and development, which are the lifeblood of the industry at present and its best insurance policy for the future.

Every forest products company, regardless of how small or large it may be, has an important research responsibility. Many large and the majority of our small forest products producing, processing, and merchandising companies still do not appear to be fully convinced of their responsibility for supporting and promoting forest products research.

Fourfold Increase in Research Needed

That many companies still do not have a real appreciation for the importance of research to their futures is indicated by the recent study, "Forestry and Related Research in North America." This study indicated that the forest products industries as a whole were investing about one-fourth of 1 per cent of their total forest products values in research in 1953. This compares very unfavorably with our national investment of about 1.1 per cent, the average investment of between 1 and 2 per cent of gross products values by all industries, and investments as high as 5 per cent by aggressive industries manufacturing products which are competitive with those made from wood. This report recommends that industries and public agencies greatly expand their forest products research programs and that approximately a fourfold increase is needed to bring our investment in forest products research to the 1 per cent of gross product value considered the minimum research investment needed to keep industries developing and competitive.

This report, which was published by and is available from the Society of American Foresters, Washington, D. C., contains the following quotes which are significant to the case in point:

"Every forest products company should make some investment in research beyond what it may contribute through taxes towards the support of public agency research. Added investment in research is good business for small as well as large companies.

"The Forest Products Research Society is the only society that covers all the forest products industries. It has stimulated research, helped correlate research, provided excellent opportunity for presentation and publication of research papers, and helped provide a measure of unity that this field has needed. Membership in the Society, even though it is not a professional group, should be a "must" for every forest products company and research worker interested in the future of the forest products industries."

Certainly the increased forest products research activity of recent years has been partly due to the stimulation of the Forest Products Research Society. The activities and accomplishments of the Forest Products Research Society have been to a considerable extent the result of the many fine contributions by all of its members and particularly by those who have given to it so much of their time and attention—our Subject Matter or Technical Committee members and their Chairmen.

The Author: Dr. Frank H. Kaufert received B.S., M.S. and Ph.D. degrees from the University of Minnesota, studied one year at University of Halle, Germany. He was associated with the U. S. Forest Service, DuPont Chemical Co., and U. S. Forest Products Laboratory before joining the Minnesota faculty. Dr. Kaufert is author or co-author of more than 50 papers and bulletins and 12 U. S. and foreign patents. He formerly served as Chairman, FPRS Publications Committee, and is Council Member, Society of American Foresters.

Vermont Furniture Firm Becomes FPRS Supporting Member

Beecher Falls Manufacturing Corp., Beecher Falls, Vt., has joined the growing list of FPRS Company Supporting Members helping promote the scientific progress of the industry.

W. J. MORRISSEY

President W. J. Morrissey is the firm's designated representative to FPRS. Associated with furniture manufacturing since 1921, Mr. Morrissey is also president of Orleans (Vt.) Mfg. Co., director of T. Baumritter Co., New York, Boonville (N.Y.) Furniture Corp., and Whitney Manufacturing Co., South Ashburnham, Mass.

Founded 75 years ago, the firm manufactures bedroom and occasional furniture, principally from yellow birch. Since northeastern hardwoods are no longer plentiful within transportation range of the mill, the company plans to discontinue its bandmill this spring.

Beecher Falls plant was recently modernized and equipped with new woodworking machinery.

The mill's annual cut of yellow birch formerly averaged 5 million feet.

The Beecher Falls firm employs 275 persons and has an annual production output of $4 million. Its products are marketed with the Ethan Allen Colonial Furniture group through T. Baumritter Co.

Meet FPRS 100 Company Supporting Members

ALABAMA
W. T. Smith Lumber Co., Chapman

ARKANSAS
The Crossett Co., Crossett
Dierks Forests, Inc., Mountain Pine
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California Redwood Association, San Francisco
L. J. Carr & Co., Sacramento
Crane Mills, Corning
Ivory Pine Co., Dinuba
National Wood Treating Corp., Oroville
Philadelphia Quartz Co. of California, Berkeley
Scott Lumber Co., Inc., Burney
Tarter, Webster & Johnson, Stockton
Winton Lumber Co., Martell
E. K. Wood Lumber Co., San Francisco

GEORGIA
Southern Wood Preserving Co., Atlanta

IDAHO
Boise Payette Lumber Co., Boise
Ohio Match Co., Coeur d'Alene

ILLINOIS
The Dean Company, Chicago
General Electric, Ill. Cabinet Plant, Rockford
Greenlee Tool Co., Rockford
Edward Hines Lumber Co., Chicago
Illinois Interior Finish Co., Chicago
Johnson & Carlson, Chicago
Masonite Corp., Chicago
Mattison Machine Works, Rockford
Sherwin-Williams Co., Chicago
Steger Furniture Mfg. Co., Steger

INDIANA
The Dunbar Furniture Mfg. Co., Berne
National Homes Corp., Lafayette
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Curtis Co. Inc., Clinton

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MASSACHUSETTS
Draper Corp., Hopedale
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MICHIGAN
Baker Furniture, Inc., Grand Rapids
The Dow Chemical Co., Midland
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MINNESOTA
Mereen-Johnson Machine Co., Minneapolis
Rilco Laminated Products, Inc., St. Paul
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MISSOURI
Monsanto Chemical Co., St. Louis

MONTANA
Intermountain Lumber Co., Missoula

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Vaughn Millwork Co., Reno

NEW YORK
American Defibrator, Inc., New York
Behr-Manning Corp., Troy, N. Y.
Borden Co., New York
Peter Cooper Corps., Gowanda
Georgia Pacific Plywood Co., New York
Oval Wood Dish Corp., Tupper Lake
Reichhold Chemicals, Inc., White Plains
U. S. Industries, Inc., New York
United States Plywood Corp., New York
The Upson Co., Lockport

NORTH CAROLINA
Deluxe Saw & Tool Company, High Point

OHIO
The Baldwin Piano Co., Cincinnati
Coe Manufacturing Company, Painesville
The Kirk & Blum Mfg. Co., Cincinnati
Moraine Box Company, Dayton

OREGON
Cascades Plywood Corporation, Portland
Forest Fiber Products Co., Forest Grove
Mater Engineering, Corvallis
J. Neils Lumber Co., Portland
Oregon Lumber Co., Baker
West Coast Lumberman's Assn., Portland

PENNSYLVANIA
Blaw-Knox Company, Pittsburgh
Fifth Sterling Corp., Pittsburgh
Koppers Company, Inc., Pittsburgh
Perkins Glue Co., Lansdale
United States Steel Homes, Inc., Harrisburg
Wood Metals Industries, Inc., Kreamer

SOUTH CAROLINA
Lightsey Brothers, Miley

TENNESSEE
E. L. Bruce Co., Memphis
Chapman Chemical Company, Memphis
Memphis Hardwood Flooring Co., Memphis
Nickey Bros., Inc., Memphis

TEXAS
Wm. Cameron & Co., Inc., Waco
Kirby Lumber Corporation, Houston
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VERMONT
Beecher Falls Mfg. Corp., Beecher Falls
Fyles & Rice Co., Inc., Bethel

WASHINGTON
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FPRS Forest Products Journal

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FPRS Annual Review

Forest Products in Review

The following special reports present the second FPRS Annual Review of technical developments and trends in major segments of the forest products industry. Prepared by FPRS Subject Matter Committees, the reports have a two-fold purpose: To keep our members abreast of significant technical changes taking place in a dynamic forest products economy, and to provide a ready reference of selected bibliographies of the outstanding papers and publications by fields.

Developments in Logging—1955[1]

GEORGE J. CARR

Chairman, Logging Division, FPRS Logging and Milling Committee[2]

Reviews new developments in all phases of the logging operation, including timber cruising, job layout, road-building, felling, bucking, yarding, loading, hauling, communications, and safety. Contains bibliography of literature on logging.

LOGGING INDUSTRY DEVELOPMENTS are discussed in this report in the normal sequence for average logging operations.

Cruising and Job Layout

New volume tables have been developed for the various species in the Northeast, Lake States, and Central States areas. An ever increasing portion of the smaller sawmills are basing their log purchase prices on some type of grading system. Research, development and instruction interest in log and tree grades continued this year at the various universities, forestry schools, Tennessee Valley Authority, U. S. Forest Products Laboratory, and the U. S. Forest Experiment Stations. Loggers and timber owners benefit from such improved tables since they are assured that cruise appraisals are more accurate.

Air photos are being more widely used. Advances in photographic technology, interpretation, and the training of personnel in this field are encouraging more operational planning, i.e., road locations, cutting, and job layout with a minimum of ground contact. Accuracy, time saving, and cost are the factors stimulating progress in this field.

Road-Building

The crawler tractor-dozer continues to be the work horse for both pioneering and maintenance of logging roads. Notable equipment improvement in this field has been the acceptance of the "Semi-U" type dozer as a pioneering tool for mountainside road-building in lieu of some angle-dozer units on the Pacific Coast. The "Semi-U" blade is claimed to have the light weight, short overhang, maximum maneuverability characteristic of the straight blade with the cutting-in ability of an angle blade and without the angle blade "sucking-in" tendency. It carries more dirt than the straight blade, but has been observed as cutting

Fig. 1.—Clark–Michigan rubber-tired tractor Model 175 with loading tongs and hydraulic drive Carco winch, loading an International truck at a California operation.

[1] This report was submitted through Fred C. Simmons, Chairman, FPRS Logging and Milling Committee.

[2] Members of the Logging Division are: J. A. Doyle, E. E. Matson, N. C. F. Nielsen, David E. Herrick, George J. Carr, Chairman.

The Author: George J. Carr attended U. of Minnesota, has been associated with Pacific Car and Foundry Company for 16 years. He has served successively in the parts and service office, sales office, as field representative, Eastern Branch Manager, and is now General Sales Manager. In his work, Carr has observed logging operations throughout the United States, Canada, and Mexico.

Fig. 2.—International–Drott shovel loader unit, illustrating interchangeable blades. Left, loading a truck, and right, land clearing attachment with break-out force of more than 50,000 pounds.

into logs in an unsatisfactory manner on the cold deck.

Several new models of crawler tractors have been introduced during the year. A trend towards increased horsepower is noted in the larger tractors, and an increased proportionate use of smaller crawler tractors is worthy of note.

In the rubber-tired tractor and tractor-scraper field there is some indication that both the dozer variety and its scraper component are being increasingly used for maintenance and construction of the higher class, primary logging roads. The equipment and methods are largely a duplicate of accepted practice on conventional road jobs, with the exception of the multipurpose attachments, i.e., interchangeable loading tongs, dozer blade, landclearing blade, and winches. Fig. 1 illustrates a typical rubber-tired dozer-shovel loading logs. The same type unit with bucket or dozer attachment is used on road maintenance.

Fig. 3.—Chain saws are increasing in popularity in big timber, hardwood, and pulpwood operations.

In the past year, variations of the crawler-tractor-mounted front-end shovel have been experimented with as pioneering, landclearing, grade building, and log loader units. The higher reach (height) of these units, interchangeable attachments, and the crawler tread for tractive effort in varied conditions are primary factors in the application of this equipment. Fig. 2 shows a combination which has received considerable attention by the industry during 1956 in clearing stumps, trees, etc., for road building, using the grubber blade for stumps and tree removal, then shaping roads with a bull-angler dozer which interchanges with the grubber. This particular angle-dozer can be tilted hydraulically from the seat. This unit is also equipped with a winch which is used in skidding operations.

In a Southern swamp logging operation this year, a combination of the drainage operation using draglines and the "spoil pile" in conjunction with the logging haul road layout was employed with obvious aid to the logging chance. Similar dual purpose use of the fire-lanes has been noted.

Felling and Bucking

The declining trend in the use of hand saws in both the United States and Canada continued this year. The use of power tools that incorporate the advantages of increased production per man day, less physical strain on the worker, and closer utilization of the timber is the popular trend (Fig. 3).

Some functional improvements in chain saws have ben effected, notably in their mechanical efficiency and lighter weight. Silencers have been introduced recently in an effort to reduce noise and improve overall operator well-being. The development of higher speeds on chain saw chains is noteworthy. The direct drive saws which eliminate the belt or gear reduction between the engine crankshaft and the saw sprocket are the most radical development in this line. The first saws of this type used previous high-speed, low-torque engines and had speeds of 5000 to 7000 lineal feet per minute on the chain. These high speeds were observed to give notable improvements in cutting, particularly in reducing kick and grab.

Limbs and brush could be cut with the tip of the bar, top or bottom, with ease, and boring cuts through the log could be started through the side of the log with little or no tendency for the blade to kick up. At these speeds, however, there was a greater tendency for the saw to stall in pinches or heavy cuts. Also, greatly increased wear on the guide bar shoulders and chain links was noted.

It was discovered that the advantages could be maintained and the disadvantages reduced by somewhat lower speeds on the chain, in the neighborhood of 2000 to 3000 lineal feet per minute. Most direct drive saws now coming out have lower-speed higher-torque engines turning the chain at about these speeds. Many gear or belt reduction saws have altered their ratios to get up into the same speed range.

These high-speed saws, so far, have attained their greatest success in pulpwood operations. Recently, however, one company has brought out a 6 h.p. direct drive saw; and a 5 h.p. model made by another company has won several log cutting contests. The problem of increased wear on the guide bar and chain parts seem well on the way toward correction by better alloys and hardening methods. It is suggested that loggers who may have experienced

failures in their early attempts to employ power saws in logging operations should re-check the improved equipment currently available.

The reciprocal-type power saw also has entered the U.S. field. Such features as lighter weight, safety, and low maintenance are emphasized.

Early results from a Central States Forest Experiment Station study in progress in southern Illinois illustrate the importance of the bucking operation as an influence on the value of the logs produced. This study involved approximately 55,000 board feet of oak logs bucked by nine different commercial operators. Results indicate that, by more careful bucking, the volume of grade logs produced could have been increased by about 45 per cent. Where logging is conducted by the small mill operator, such an improvement in grade could result in an increase in margin for profit and risk of more than 100 per cent. The log grades used in these studies were the factory lumber, interim structural, and local-use grades developed by the U.S. Forest Products Laboratory.

Yarding and Skidding

During the past year there have been relatively few new developments in accepted practice for this field. The conventional highlead cable, tractor drawbar, arch logging, and pallet or bundle haul continue to find their application practiced according to the logging chance involved. Some new items of equipment, however, are being applied to the conventional harvesting methods.

The Wyssen system, a European cable method, appears to have some support from U.S. Forest Service personnel. The technique has possibility, particularly as a long distance cable system for logging precipitous slopes with minimum damage to the residual stand. It will require refinement to bring it to acceptable U.S. economic and safety standards, especially for use in big timber. Bundle yarding, a variation of conventional highlead systems, is used to some extent for skidding pulpwood in Ontario. The trend in this area seems to be toward use of self-propelled yarders.

Several more portable steel spar trees for use with tractor-mounted double-drum hoists were put into service this year on the West Coast. The Priest Spar by Berger Engineering Company and the folding spar developed by Washington Iron Works for Crown Zellerbach have commanded Northwest loggers' interest. These spars are portable, cut down rigging and moving time, and are adaptable to conventional highlead methods. Fig. 4 shows a typical steel spar operation. Relogging in steep terrain for greater timber utilization appears to be an application ideally suited to the steel spar technique.

Another relatively new equipment item observed this year is the combination yarding and loading crane. "Cherry pickers," as this type equipment has been called in the Idaho pine area for many years, have changed from the blacksmith shop, homemade style to the factory designed and produced units, as illustrated in Figs. 5 and 6.

In the tractor-yarding field, little functional change has been achieved in method. Drawbar skidding, arch, or log cart practice have retained their relative proportions in the industry when measured in volume of wood produced. A trend towards rubber tires for logging arches or log carts over the conventional truss-type crawler wheels is evident (Fig. 7). While more difficult ground conditions still dictate the crawler load carrying wheels on arches for average operations, more than 50 per cent of the new tractor-drawn arch units being purchased have rubber tires instead of crawler wheels.

Renewed efforts have been made to statistically tabulate skidding operations using current equipment and utilization practice for the areas studied. The Kaskaskia Experimental Forest Service Study and the Michigan College of Mining and Technology, Upper Michigan test operations, provided interesting treatment of skidding fundamentals.

Fig. 4.—Portable steel spar tree appears adaptable for re-logging in steep terrain.

The Kaskaskia report is nearing completion. This study was in four phases: a) skidding resistance of various sized logs; b) skidding production comparing drawbar, pan, and sulky or arch skidding; c) damage to residual stand; and d) log weights. Current status of the four phases of this study is as follows:

a) Skidding resistance. Tests involving ground and sulky skidding of various-sized log loads over a range of

Fig. 5.—Yarding and loading crane, a Washington Iron Works unit, is shown in yarding phase at Washington operations.

Fig. 6.—Heil boom loading a Kenworth truck in Pacific Northwest fir logging operation.

Fig. 7.—Rubber-tired Carco logging arch behind International TD-24 tractor on Weyerhaeuser Timber Co. re-logging operation.

slopes have been completed. Results[3] show that: (1) skidding resistance coefficients for use in computing the tractive force required to ground-skid log loads can be determined and successfully applied; (2) the tractive force required to ground- or sulky-skid log loads varies directly with slope and load weight; (3) the size or number of the logs included in a load has no significant effect upon resistance to skidding; (4) on level terrain, sulky skidding required less tractive effort than ground skidding for all loads weighing in excess of 500 pounds; and (5) the advantage of sulky skidding increases with slope for downhill hauls but decreased for uphill hauls.

b) Skidding production. Tests using 38, 43, and 66 h.p. crawler-type tractors to ground and pan-skid log-length loads and to sulky-skid log- and tree-length loads show that: (1) the time required to travel from the log deck to the bunching point (empty run time) is not influenced by tractor size or skidding attachment; (2) the time required to bunch a given volume of logs is influenced by tractor size, attachment used, number of logs involved, and the distance covered in assembling them; (3) when ground skidding, the haul time per 1,000 board feet, per 100 feet of distance, is considerably less over a prepared skid road than over an unprepared trail; (4) size of the optimum load for a given tractor increases with slope for downhill hauls and decreases with slope for uphill hauls; and (5) when a prime mover is either underloaded or overloaded, production rate drops rapidly.

c) Logging injury. An evaluation of damage to the residual stand resulting from the production phase of the study indicated that, under conditions similar to those encountered: (1) regardless of the equipment combination used in either log- or tree-length skidding, injury is confined chiefly to sapling-sized trees; (2) bunching with a sulky or an arch will result in the least amount of disturbed area and the smallest number of injured trees per 1,000 board feet bunched; and (3) there is no appreciable difference between log-length and tree-length with respect to the influence upon the overall level of stock of the residual stand.

[3] Herrick, David E. 1955. Tractive effort required to skid hardwood logs. Forest Products Journal V (4): 250–255.

(Detailed reports on phases a), b), and c) above will be released within the next few months).

d) Log weights. A first draft of the report on log weight tests is being prepared with analysis of the data developed in the skidding production phase. By weighing approximately 250 southern Illinois oak logs, it was found that the weight of a freshly cut log can be successfully estimated from its volume, but the weight per board-foot varies between species, between top logs and butt logs, and by log size. Publication is expected to follow the earlier completed phases of these studies.

In the Lake States area, a modern version of the "log bummer" has appeared. It is a hydraulic self-loading, tractor-drawn unit. Ease of handling and maneuverability, even with inexperienced operators, are features of this unit. Disadvantages include limited load capacity and its inability to discharge the load whenever necessary so that the prime mover can move ahead to better ground footing, then retrieve the load during the hauling cycle and proceed according to conventional practice.

Rubber-Tired Units

The past year has seen continued logger and manufacturer interest and experimentation with rubber-tired yarding units. It is recognized that a satisfactory rubber-tired tractor-arch unit may find increased logger acceptance, particularly as a swinging unit. This equipment offers promise in the field of reduced truck haul with the attendant less expensive road building costs. A brief summary of independent field reports covering some units observed on test operations during the past year reveal the following:

Le-Tourneau–Texas — West Coast type heavy duty unit, embodying 4-wheel electric-drive concept, two wheels being prime mover and two wheels being arch wheels. Basic overall design appears good; however, it needs to be fully tested for load distribution and performance in the area for which it is designed.

Le-Tourneau–Westinghouse—Two units available, one similar to the above-mentioned rig, the other a 4-wheel-drive tractor using conventional tractor drawn arches. At present, the latter appears to have captured the

Fig. 8.—Caterpillar DW-20 wheel tractor in experiment with integrally mounted arch and Hyster winch.

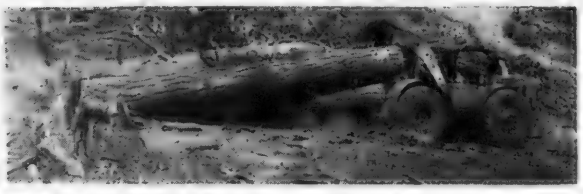

Fig. 9.—Westfall Performer yarding load of pine logs in high-speed movement to truck landing.

best sales record for rubber-tired yarding units.

Caterpillar DW-20 — An experimental 4-wheel-drive rubber-tired tractor with integrally mounted arch, winch, and bulldozer (Fig. 8) was field tested on western logging operations for 13 months in British Columbia, Idaho, Montana, California, and Washington. The purpose was to determine the suitability of the tractor and its application in woods work. The primary tests on all logging jobs were yarding logs; however, it was also used to push load scrapers, maintain roads, clean out ditches, feed gravel to a crusher, push loaded trucks up heavy adverse grades, load logs, and pull a road roller. From the tests it is believed that rubber-tired tractors complement the use of track-type tractors and they should be used as a team to reduce truck road construction costs by increasing the yarding distance. Caterpillar engineers feel there is a definite place for rubber-tired tractors in logging operations and this company is considering the manufacture of this unit for logging and other markets.

Westfall Performer—This unit, a truck type arrangement with integral winch and arch (Fig. 9) is reported by the manufacturer to have demonstrated sufficient capability to encourage company development in three sizes. Approximately 18 units are reported to be in operation in British Columbia and western United Staes operations. One is in use in West Virginia. Other uses than logging application may stimulate development of these 4-wheel-drive tractors.

Wagner Logmobile—This appears to have the ingredients for potential challenge in the field. Weight, balance, drive, and articulation between prime mover and arch unit are factors given consideration in this unit. To date field experience appears experimental; originally this was a light weight, comparatively less expensive unit.

FWD Blue-Ox—This unit appears to have been "beefed up" this year and may therefore gain greater acceptance. Recent modifications have given it closer affinity to Eastern pulp and softwood markets. Timberlands, Inc., Dixfield, Maine, (where the Blue Ox was developed) now has six of these machines and claims that they have reduced the total cost of transport from stump to mill by something like 50 per cent by their use. This is primarily due to lesser road building costs and lesser wear and tear both on their hauling trucks and on their crawler tractors. They are yarding an average distance of about a mile with the wheel machines in the summer, and considerably farther on snow roads in the winter. Average loads of tree

Fig. 10.—Power Horse four-wheel drive tractor and Carco log cart yarding 10 to 12,000 board feet daily over 1¼-mile arch skidding trail.

length logs run around 1000 to 1200 board feet, and about ten trips a day are made on the summer time haul. This operation is in rolling country with fairly well drained soils.

Go-Getter—Designed primarily for work in the South, this unit has recently demonstrated its ability to perform in the swamp and low lying timber areas of Florida, Georgia, and North Carolina, and is now being incorporated into the Pettibone–Mullikin line. A limited quantity of these units are also being demonstrated in Northeastern test operations. Articulation is the featured design characteristic.

Michigan—This front end carry-loader unit has demonstrated an ability to forward 4-foot pulp from the strips on Quebec pulpwood operation. Operating costs or production capacity have not been disclosed. The manufacturer claims the combination of maneuverability in the strips and high-speed haul. At least one of these same units was also observed with winch and loading tongs used as a "clean-up" tool during this past year.

All-Drive—The Garrett unit, a modification of the TD–6 size International Harvester tractor, is gaining some acceptability in the inland pine areas of B.C., Eastern Washington, Oregon, and the Northeastern states. This type unit appears somewhat suited to park-like logging on firm undulating ground where the logging chance is favorable. The manufacturer is currently reported to be experimenting with a larger size unit.

Power-Horse—A four-wheel-drive tractor in the 40 h.p. class which has now been on the market for several years. This unit does not seem to have found a universally ready logging market to much extent beyond the typical farm type-wheel tractor market. However, Swezey Lumber Company, Manchester Depot, Vt., is highly enthused about their Power Horse (Fig. 10) which is bringing down 10 to 12,000 feet a day of tree length hardwood sawtimber off a mountain over an average 25 per cent slope on a cheaply built trail about a mile and a quarter long. An HD–5 Allis–Chalmers crawler tractor is doing the bunching at the top.

Austin-Western—A pilot unit was tested at Brown Company in Maine with no published conclusive reports. Re-design apparently was suggested by the experience gained.

Berger—A 4-wheel-driver tractor in the 45 h.p. class has been observed as in experimental stages for several years with no conclusive published reports.

Mark IV Bonnard Logger—A rubber-tired tractor with integral winch designed to transport one- to two-cord bundles of 4-ft. wood from the stump to landing. The load is carried in a frame suspended over the rear wheels. The unit which has been used in eastern Canada on an experimental basis to date features articulation. Users feel the unit holds considerable promise for the transport of 4-ft. wood.

As a general comment regarding the application of the smaller sizes of rubber-tired units, user troubles have centered around the steering clutches, weak points in the frame structure, use of truck-type winches, and balance problems. These are slowly being corrected.

Since most users stopped attempting to add weight for better traction by using water or calcium chloride in the tires, tire difficulties have been almost nonexistant. Low air pressure seems to be essential for protection against blowouts and for maximum traction. Inner-liners are being prevalently used

Fig. 11.—Conversion tracks for wheel tractors give better traction in more difficult terrain.

in the tire casings for blowout protection and to spread the tread for greater traction. Weight can be satisfactorily added by wheel discs, bumper equipment, etc.

Another improvement in wheel tractor operation for woods work has been the conversion tracks, as illustrated in Fig. 11, for better traction in more difficult logging terrain.

In reviewing the many test vehicles and experimental application of these rubber-tired tractor units, one must certainly recognize the industries' interest in providing equipment capable of lower maintenance and operating costs for the logging operation. Search for this goal in rubber-tired skid and haul units is in the experimental stage.

In total, all of the rubber-tired special-purpose logging units in operation this year comprise a small segment of the total logging tractor units operated during the year. Ratio of rubber-tired to conventional crawler units (exclusive of farm tractors) is estimated to be one in 2 or 300.

Loading

Cable loading is declining in popularity in the West and is gradually being supplanted by the heel boom types. The heel boom technique, spilled over from Idaho, is continuing its swing to dominance in heavy timber loading. Self-powered cranes, and truck cranes are also increasing in popularity in the East. Both types appear highly suited for handling, pulp and sawlogs. The increased acceptability of the truck cranes reflects better hydraulic systems, and the general versatility of this equipment for the small operator. The increased use of steel strapping of logs, so that entire loads can be removed from trucks, gondolas, or flat cars in one lift, has been noted.

The use of strapping is of value in obtaining more scale in a log raft, and it prohibits the hemlock sinkers from falling out of the raft. Strapping or cable bundling of pulpwood bolts in the Eastern States still seems to be in an experimental stage.

Air tongs on loading rigs continued to find additional logger acceptance this past year in the fir and western pine operations.

Tractor-loaders of the front-end crawler type appear to be holding their own. It seems that logging circumstances confine their use only in well defined areas and conditions. Conversely, front-end loaders of the rubber-tired type appear to be on the increase when compared to their previous share of the market.

This year demonstrated the West Coast salvage operation as an area of promise for the fork-equipped rubber-tired unit. It appears that rubber, as demonstrated this year, will make increasing inroads in the hitherto exclusive domain of the crawler tractor in this field.

Hauling

The truck has long been the undisputed leader in the transportation cycle of the wood haul. Little change in this picture developed during the year, with the exception of the aforementioned experiments with rubber-tired tractor units and their potential use for "swinging" loads to the truck roads.

Truck developments continued along traditional lines, i.e., increase in performance. Heavy-duty off-highway trucks were introduced this year in the West using 16-ft. divided bunks to facilitiate load transfer to standard 8ft. highway bunk equipment. Specific log hauling attachments were noted in the spring-loaded high-stake bunks and various adaptions of "slip-on" high stakes for field conversion of standard bunks (Fig. 12).

Fig. 12.—High stake bunks and other safety standards are being legislated as mandatory for public highway use in Oregon.

An increase in railroad hauls is noted as the timber continues to travel further distances to the mill. Full-load transfer lifts from off-highway truck hauls to long-haul rail transportation is a part of this trend. Load transferring techniques received the most attention with appreciable strides made in the use of lift-fork type units for side loading on smaller jobs.

A cable hauling system of European variety was tried this year in Eastern Canada. It consisted of an endless cable that works on the order of a ski tow. Carriages loaded with about 1/3 cord of pulp are hooked to the moving cable, and taken by gravity some 4 miles down slope to a transfer area. From the transfer area, the wood continues in conventional manner to the mill.

The river drive continues as a method of moving a sizable volume of wood in the traditional river drive areas. However, litle variation in the technique was noted this year. Several new "splash dams" were installed on West Coast operations during the year.

Communications

Two-way radio continues to make inroads on the major operations. The usual features stressed are: organizational liaison, less down time, and the emergency communications emphasis.

Safety

Last year showed a growing trend toward the use of tractor canopies in the East. State law makes these compulsory in the West. The result of intensifying safety and workmen's compensation thinking occasions the increased demand for such devices.

Recent legislation in Oregon is calling for high stakes on log bunks for public highway use; also, more binder chains are required as a result of numerous highway accidents due to logs falling off. All log trucks hauling loads of more than 500 board feet in New York State are now required to have safety-trip stakes.

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Developments in Milling—1955[1]

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Discusses economics of sawmill industry, increased lumber production, trends in milling equipment and methods, wood residue utilization, and progress in research and development. Contains bibliography of literature on sawmilling.

THE SAWMILL INDUSTRY in 1955 provided an interesting study in contrasts: the industry enjoyed a very high level of prosperity, but at the same time witnessed the closure of a large number of mills.

Prosperity in the general economy itself was the reason for many mills going out of business, particularly small mills in the Southeast which were unable to cope with the increasing labor costs brought about by competition for labor. It is estimated that several thousand marginal operators in the Southeast alone quit during the past two or three years.

In the Northeastern region, a number of small marginal operators also were going out of business, though many of these were quickly replaced with new small mills. In the Pacific Northwest, several important large and medium sized mills closed due to lack of logs and the high cost of available stumpage. Stumpage availability and costs were a major problem in many regions of the United States.

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Lumber Production

All of the 14 timber regions into which the United States and Canada naturally fall reported great activity, many breaking production records over previous years. Particularly noteworthy were the increased production of hardwood mills.

In the Northeast, hardwood production showed a marked increase, especially in maple and birch. There are indications that yellow birch could be pricing itself out of the market, and there is a consequent increased interest in hard maple as a substitute. Eastern Canadian hardwood mills approached record production during 1955.

The Northwest hardwood industry now has about 40 mills in Oregon and Washington, with production increasing one-third over previous years. The emphasis in this region is on increasing quality manufacturing. Expectations are that increased hardwood lumber prices in the East due to increased minimum wages will give Northwestern mills an opportunity to raise prices and make a profit. The industry has reached the point of organizing a Northwest Hardwood Association to promote the sale of hardwood lumber and to set up standards.

Trends in Equipment and Methods

In many sections of the United States, the new minimum wage law which does not go into effect until 1956 has already influenced mill trends. In the small log regions where portable mills have made up the bulk of sawmills, the trend is to larger and heavier mills with greater productive capacity. These new mills are utilizing new automatic machinery to reduce labor costs. New large mills are rare in these regions. Interest in gang and band mills continues.

Many small log mills are utilizing edgers, log ponds, live decks, trimmers, resaws, and green chains for the first time as part of their efforts to increase productivity. In the Southeast, many concentration yards have had to purchase sawmill machinery and go into milling because their suppliers have been getting fewer.

In the large log regions of the Pacific Northwest and California, mills built for cutting large diameter logs are finding it necessary to put in pony rigs and other equipment to handle the increasing volume of small diameter logs going through the mill. Mill modernizations in this region are generally involved in shifting mill facilities to accommodate with greater efficiency the large percentage of small diameter logs and to sharply increase productivity.

New mills in this region trend to the 40–100 M ft. per shift size, with an increased use of gangs for small diameter logs and bands in low volume mills. Automatic decks, automatic carriages, gangs for single headrig mills, line bar resaws, and other new equipment rapidly replaces old-style conventional set-ups in high productivity mills.

Debarkers are slowly creeping in as part of mill equipment. The Northeast softwood region installed four barkers in 1955. Northeastern Canada had five more barkers. The hardwood regions were likewise debarking. More

barkers are coming into use in the intermediate size mills in the Northwest.

Wood Residue Utilization

While startlingly new methods for wood residue utilization were few, mills were practising a high degree of wood utilization. Chipped waste for pulp mills and the use of sawdust in agriculture were the most prominent forms of utilization, though in the Appalachian region the production of charcoal from sawmill waste increased and many mills continued to sell hogged residues for fuel.

In the Northeastern softwood region 3000 to 5000 cords of chipped waste for pulp mills were produced, compared with 400 cords in 1952. In the Northwest, a high pecentage of the total sulphate pulp production now comes from sawmill residues. In Northeastern Canada, two plants are now producting edge-glued lumber panels from low-grade white pine, providing an economic disposal of low-grade lumber from this species.

At Alcoa, Tenn., Edge Grain Timber Products is producing edge-grain doweled laminated flooring at the Veach–May–Wilson, Inc. Plant. This process promises to recapture part of the industrial flooring market for wood.

Research and Development

Considerable research and development for the industry was carried on at the various colleges of forestry and research laboratories. An index of increased research are the growing facilities: a new laboratory at the College of Forestry, State University of New York; projected new laboratory at the Forest Products Laboratory at Ottawa; and new research laboratories of the Crown–Zellerbach Company, Camas, Washington. Poinsett Lumber and Manufacturing Co. at Pickens, S. C. has been set up as the research laboratory for the Singer Sewing Machine Co. Considerable research is being undertaken by the Yale Forest School under the Hartford Foundation Fund at Valhalla, New York.

Many interesting studies are underway. The Forest Products Laboratory at Ottawa is experimenting with a sawmill with a travelling circular headsaw past a stationary log. The University of Missouri is studying grade return on three sawmills in Missouri; it is also experimenting with making paneling out of low-grade oak lumber and is running a pilot plant with the U. S. Forest Service for better utilization of trees. Iowa State College is doing research on wood gluing, Purdue University on wood laminated beams, and the University of Illinois on the use of native wood for construction.

The University of Washington has a research project on the use of alder for sawlogs and pulpwood. This University received the John H. Hauberg, Jr. research grant for the support of studies in the field of alder utilization. The Oregon Forest Products Laboratory is studying the preservation and treatment of tanoak for use in Navy shipbuilding.

The Ford Forestry Center at Alberta, Michigan, a gift of the Ford Foundation to Michigan College of Mining and Technology, is presently being activated. The Center consists of a village of 12 residences, two school houses, and a sawmill, with three sections of hardwood timberland. The sawmill (6-foot band, edger, and trimmer) is being converted from steam to electric power for flexibility of operation in teaching and research. The facility is excellently situated for demonstration and it is planned to incorporate in the mill any practical new equipment as it is developed. The operating plan for the center includes short courses in sawing, filing, grading, and other sawmill techniques.

Automation and its effect on sawmilling was a topic of absorbing interest to mills. One large western lumber manufacturer has undertaken a major research and development program with the objective of automating its operations. The program includes the development of mill plans and equipment for an automated sawmill.

Meetings and Conferences

The Eastern states were very active in promoting sawmill training conferences. A sawmill training course was held in Pennsylvania, two in New York, and three in Vermont. Instruction was given by college faculties, the Forest Utilization Service of the Northeastern Forest Experiment Station, and the U. S. Forest Products Laboratory. A record 10,000 people attended the Woodsmen's Carnival at Galeton, Pa. The Logging Show in Kentucky in October was well attended.

Many logging conferences were held in the Western states, but few had programs geared to sawmill interests. The Northwest Section meeting of the FPRS in October was essentially a milling session.

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Our Changing Veneer and Plywood Industry[1]

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Discusses developments in the past year and future trends in the United States and Canadian veneer and plywood industry, its equipment, and its processes. Bibliography lists important American reports published in this field in past year.

IN THE YEAR 1955 the veneer and plywood industry was dominated by a spirit of optimism. An attitude of favorable self-appraisal can be attributed primarily to a year of phenomenal and unpredictably large increase in plywood production and sales. Aggressive promotional activities by the major trade associations of veneer and plywood manufacturers, and also by the manufacturers themselves, seemed to bring immediate returns.

A look into the future was provided by the Stanford Research Institute Report on *America's Demand for Wood —1929–1975,* that provided facts, figures, and estimates for intelligent thought and discussion. The report predicts that the total production of softwood plywood will go to about 7.2 billion square feet (3/8-inch equivalent) by 1975, and production of hardwood plywood to about 2 billion square feet.

Much discussion of future trends also accompanied the reminiscing on 50 years of softwood plywood production at the Golden Jubilee meeting of the Douglas Fir Plywood Association in Portland in June 1955. This was probably the biggest congregation of plywood manufacturers, industry suppliers, and plywood sellers and users in the history of our country.

Plywood manufacturers also considered the *Timber Resource Review,* a review of current timber supplies and a prediction to the years 1975 and 2000, published in preliminary form by the U. S. Forest Service. Some optimists quoted statements to the effect that timber growth and drain were finally in balance, but overlooked the report's warning that increasing future needs might again upset that balance, and that veneer quality timber would in any case be in short supply in the future.

Within the year that has elapsed since the Stanford Report was first released, plywood production figures have far exceeded the projected figures of that report. Yet one must not forget that, as time's pendulum swings to and fro, the actual sales curve might just as easily dip below the predicted curve. At the close of this favorable year therefore, one can only hope that the talk, the thinking, and the introspection of the industry leaders may bring about an awareness that future growth and expansion depend not only on promotion and sales activity, but on the adoption of long range forest manage

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ment policies and on technical development and research.

That the industry will give greater support to research in the future seems assured. The U. S. Plywood Corporation has announced plans for the building of a research laboratory. Industry-sponsored research at private and public laboratories may also be expected to increase. Of interest here is the plan of the State University of New York College of Forestry, Syracuse, to install complete equipment for veneer and plywood research in its new forest products laboratory. This will be the third research center in the United States capable of conducting a unified research program from log to finished plywood product, the other two being the U. S. Forest Products Laboratory, Madison, Wis., and the North Carolina State College of Forestry, Raleigh. The Forest Products Laboratories of Canada also have a veneer and plywood research laboratory at the Ottawa branch.

Growing Industry

Douglas-fir plywood production in the western United States, which amounted to 3,670 million square feet (3/8-inch, 3-ply equivalent) in 1953, totalled 3,903 million square feet in 1954 and 4,900 million square feet in 1955. In addition, 255 million square feet of ponderosa pine and sugar pine, 25 million square feet of redwood, 93 million square feet of spruce, 65 million square feet of hemlock, and 6 million square feet of cedar plywood were produced in 1955. The total production of softwood plywood in the United States in 1955 is estimated to be about 5½ billion square feet on a 3/8-inch, 3-ply basis.

About one-fourth of the Douglas-fir plywood produced in the U. S. was of the exterior type in 1955, as it was in 1954 also.

Much Douglas-fir plywood is now produced in plants cooperatively owned by the workers.

The trend continues toward the establishment of green veneer plants in the softwood industry, as reported a year ago. Of a total of 180 U. S. West Coast softwood veneer and plywood manufacturing establishments, 66 produced veneer only.

The production of domestic hardwood plywood in the U. S. will be considerably higher in 1955 than it was in 1954. Production figures for 1954 amounted to 658 million square feet, surface measure, of veneer core plywood; 57 million square feet, surface measure, of lumber core plywood; and 225 million square feet, surface measure, of container and packaging plywood. These figures are based on Bureau of Census reports, which do not include "captive" plywood or plywood not produced for market. This production was estimated to be 377 million square feet in 1954.

The total domestic hardwood plywood production for 1954 was about 1,318 million square feet, surface measure. On the basis of figures for the first three-quarters of 1955, it appears that 1955 production will run from 22 to 26 per cent above the 1954 figures. It is expected that total hardwood plywood production for 1955 will reach a new high of 1.5 to 1.6 billion square feet, surface measure.

The Canadian softwood plywood industry, which in 1952 manufactured 464 million square feet of plywood (¼-inch thickness basis), manufactured 663 million square feet in 1954, and an estimated 684 million square feet during the first half of 1955. All Canadian softwood plywood production is of the exterior type. Canadian hardwood plywood production for 1954, on a ¼-inch thickness basis, amounted to 161 million square feet, as compared to 156 million square feet in 1953 and 131 million square feet in 1952.

Plywood imports to the United States, primarily of hardwoods, amounting to 220 million square feet in 1953, grew to 434.5 million square feet in 1954. Imports in 1955 have increased substantially, particularly from Japan, so that it is estimated that the total volume of hardwood plywood imported in 1955 will be from 650 to 700 million square feet.

Uses for Veneer and Plywood

Estimated end-uses for softwood plywood in the U. S. in 1955 were as follows: residential, 29%; industrial, 42%; farm uses, 10%; commercial and public, 14%; and federal government, 5%. Hardwood plywood was used as follows in 1954: furniture and home appliances, 33.5%; millwork, 37.9% (this figure includes fixtures and miscellaneous, 15.0%; kitchen cabinets, 9.5%; flush doors, 12.0%; and department stores, 1.4%); other home construction, 11.8%; and industrial uses, 16.8%.

The use of plywood in residential construction has been growing rapidly. General acceptance has been attained for interior paneling, sheathing, and subflooring. Hardwood plywood has been used more extensively in kitchens, including even such uses as wood doors on steel cabinets. In the field of exterior wall covering, progress has been slow, but recent technical developments as well as promotional efforts on the part of the softwood industry have been aimed at this market. New exterior siding panels include "Texture One-Eleven," a rough-surfaced, grooved exterior fir paneling; paper plastic overlaid plywood lap siding; and wide overlaid bevel siding.

The use of hardwood plywood for furniture expanded greatly in 1955. The introduction of a practical process for making cigarette-proof and alcohol-proof surfaces on fine furniture panels will help to win back markets lost in this field in the past. Plastic materials, though competitive with wood, are being combined with plywood to give superior decorative panels for such uses as table and bar tops. Even for such highly specialized uses as school desk tops, overlaid plywood is rapidly gaining recognition. "Plyron," consisting of softwood plywood surfaced with hardboard, is being marketed for uses where a smooth enamelled surface is desired; this product reached the impressive volumes of 3½ million square feet in 1954 and 7½ million square feet in 1955.

Plywood wall paneling is now available, prefinished or unfinished, for use in full 4 x 8 ft. panels, or in plank, random plank, or other patterns. Annually about 50 million sq. ft. of plywood are used for flooring, primarily in the form of blocks.

The addition of preservative treatments to plywood makes it possible for plywood to compete in the field of ship and boat construction and for other uses where high decay resistance is required. The addition of fire-retardant chemicals makes it possible to use plywood in building construction in cities such as New York, where codes restrict the use of combustible materials in large buildings.

New Plywood Standards

Both the Douglas-fir plywood industry and the hardwood plywood industry announced the adoption of new standards for plywood during the year. The Commercial Standard for Douglas-fir Plywood was revised, and a new edition, CS 45–55, was published by the Department of Commerce. The Commercial Standard for Hardwood Plywood, CS 35–49, has been revised by the industry but the new standard has not yet been published by the Department of Commerce.

Changes in standards for Douglas-fir plywood provide for an "N–N Interior" grade, intended for natural finishing on two sides, as well as an "N–D Interior" grade for finishing naturally on one side. This change is in line with the current demand for plywood to be given natural finishing in housing and furnishings. For the first time this standard also provides for paper-plastic overlays of two types. A high density overlay is provided for use as concrete form material or elsewhere where a surface with high abrasion resistance and low water absorp-

tion is desired. The medium density overlay is intended to provide a durable and smooth surface for painting and enamelling.

Hardwood plywood is already being manufactured and marketed under the revised standard, even though that standard has not yet been published officially. The new standard provides for three types of glue joint: type I, having a fully waterproof bond; type II, having a water-resistant bond (withstands 10 cycles of wetting and drying); and type III, having a dry bond (withstands 2 cycles of wetting and drying). Canadian hardwood plywood is similarly produced in 3 types.

Grades of plywood that may be specified under the new hardwood standard include the custom grade, allowing for special selection by the customer; the good grade (grade 1), intended for natural finish face; the sound grade (grade 2), intended for painted surfaces; and the utility and backing grades (grades 3 and 4) intended for backs and inner plies in plywood.

In both the hardwood and the softwood plywood industry, special types and grades of plywood may be specified on special order, such as marine grade plywood or plywood treated with preservative or fire-retardant chemicals.

New Equipment

In the veneer cutting field, more equipment is being developed specifically for handling smaller logs and more defective timber. Automatic lathe loading and centering equipment is making the small lathe more economical for the cutting of smaller timber. Smaller spindle diameters are being considered in some lathe designs. European lathes, some with support rollers on the veneer bolt opposite the knife to prevent bending at a small diameter, some with tubular or concentric chucks and spindles that recede to allow cutting to small diameter, are appearing on the scene. A lathe-debarker combination is in use in the softwood industry.

The handling of logs at veneer mills is being given more attention. At hardwood mills, the use of the clam-shell lifting device, instead of the conventional tongs, is proving efficient in handling small logs in quantity and in eliminating veneer wastage due to hook marks in the outer part of the log. At softwood mills, logs and bolts are usually handled in ponds until they reach the mill for debarking and peeling. Newer layout plans feature separate debarking stations in the ponds, so that bark-free bolts may be sorted and further handled in the water. This usually provides greater bolt storage, makes barker scheduling more independent from the peeling schedule, permits better sorting of bolts, and reduces indoor storage space and handling equipment normally required for bolts between debarker and lathe.

In the heating of veneer logs and bolts, some mills use a pressure cylinder which makes possible the use of steam at temperatures above 212° F., thus speeding the heating slightly. It is reported that one California manufacturer is experimenting with direct-fired heating vats which will, if successful, eliminate the need for a steam boiler. The electric heating process, under development at the U.S. Forest Products Laboratory, has not yet come into commercial development.

Heating in log lengths or even in tree lengths in water or stream is becoming common at hardwood plants that have had to rebuild their heating vats or chambers recently. By this method the veneer waste due to end checking is reduced.

Dryer Developments

In veneer drying equipment, the newest development is the direct-fired dryer which practically eliminates the need for a steam generating plant at the veneer mill. Oil or gas is burned in these dryers. Very high temperatures are attainable, but there is some question as to whether drying at temperatures of 400° F. or higher will result in satisfactory veneer from the standpoint of gluing and general performance in plywood.

Automatic dryer feeders, that reduce the labor required to feed veneer into the dryer, are coming into use. The continuous electronic moisture detector is used in many softwood veneer mills to keep the dryer operating at maximum speed with a minimum of overly wet veneer.

Electronic edge gluing equipment, in which the flow of the veneer is at right angles to the grain direction, is being perfected to the point where feeding rates of 35 feet per minute, and in some cases as high as 50 feet per minute under ideal conditions, are being reported. In order to take full advantage of this development, thought is being given to the speedy and efficient preparation of veneer stock through the various processes, as far back as the green clipper. One manufacturer has developed a system of handling veneer, through the edge gluing of cores to the mechanical lay-up of panels, that gives rise to speculation of automation in the plywood manufacturing business.

For some years there has been a recognition of the need for expanding the basic timber supply for the veneer and plywood industry by bringing into the picture the so-called little-used species, or woods of the less desirable species, and the more defective and smaller logs that in the past were not considered suitable for plywood manufacture. Within the past year there have been many examples to prove that this objective is now being attained in the industry.

Among softwood species one can point to a plywood operation built specifically to use western hemlock. Some smaller veneer mills are using second-growth Douglas-fir and salvage fir logs containing "white pocket." One large new plywood operation is subsisting on fir logs from the Tillamook burn area, cut from trees that were fire-killed over 20 years ago.

Southern yellow pine, a species not held in high regard among plywood people, is showing up more frequently in the form of sheathing plywood. U.S. Forest Products Laboratory veneer slicing tests indicate that paneling and flooring plywood may be made with edge-grain southern yellow pine face veneers. Small, knotty western white pine and ponderosa pine logs are being sliced for panel face veneers, as are also knotty flitches cut from low-grade western red cedar logs.

Similar Trends in Hardwood

A similar trend is detectable among hardwood plywood producers. Elm veneer is being used as face material in fine furniture. The southern swamp oak species are being promoted for a special line of prefinished wall paneling. Hardwood mills in the Lake States and in the Northeast are using increasing quantities of white birch and aspen logs. A furniture manufacturer is considering possibilities of producing hickory furniture, requiring plywood panels.

On the West Coast, at least one plant has been built specifically to slice veneers of the western hardwood species such as Oregon white oak, tanoak, chinquapin, laurel, and madrone. Red alder and bigleaf maple are being cut into veneer in a West Coast furniture plant. Cottonwood plywood production seems to be on the increase, particularly on the West Coast.

Gum, fir, and birch are no longer the staple diet of the veneer industry. Today's progressive veneer manufacturer is looking about to see what timbers are available that may have been overlooked in the past. Efforts are being made to utilize America's stockpile of overlooked woods. The success of these efforts is essential to the continued growth of the plywood industry.

Perhaps the greatest single technical problem facing the veneer and plywood industry of today is that of waste reduction or, stated positively, of developing more efficient ways of utiliz

ing the high quality raw material entering the mill. In some birch mills, it is reported, the cost of the logs entering the plant makes up two-thirds of the cost of the product. It would seem profitable, or even essential, therefore, that more planning and more manpower be applied to the process of getting more plywood out of the available logs.

On the whole, it is probably a fair estimate that only about 40 per cent of the log volume entering a softwood mill emerges in the form of finished plywood; in a hardwood mill the figure is closer to 30 per cent. Wood not converted into plywood is not wasted. At hardwood plants it is used for fuel or sold to pulp plants. In softwood plants, practically all veneer waste and peeler cores are now made into pulp chips because fuelwood has been replaced by oil or gas. Yet no one can deny that $200 logs make expensive chips or fuel.

Many veneer and plywood producers are not aware of the magnitude of the losses occurring in the various steps of the production process. Only a handful conduct thoroughly modern and efficient production control systems, including continuous process inspection, followed by statistical analysis of inspection data, and this, in turn, followed by a determination of the causes for losses, and action to reduce such losses.

It is in this field that technical advances are most urgently needed in the American veneer and plywood industry.

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Developments in Glues and Gluing[1]

ALAN A. MARRA
Chairman, FPRS Glues and Gluing Committee[2]

Describes basic functions of wood adhesives and traces recent trends in glues and gluing. Innovations have come from new glues or modification of old glues, new catalyst systems, new heat application methods, new equipment, different constructions, new methods of processing stock, and new ways of evaluating performance. Reports areas where further research is needed and where studies are now underway.

ONE OF THE OBJECTIVES of a subject matter committee is to keep the membership informed of new developments in its field. Since it is desirable to do this on a non-technical level and in brief summary form, it would appear appropriate to initiate the series with some background information by way of establishing the present status. Thus innovations may be viewed as part of a series of trends which have existed for some time and may be expected to lead to further developments.

During the past two decades the gluing of wood has become increasingly more important in the conversion of timber into marketable forest products. Although wood had been glued successfully for several thousand years, the art of gluing owes its present importance to comparatively recent developments.

Two events have figured prominently in the phenomenal rise of wood gluing: (1) the development of new adhesives, particularly those of the synthetic resin type which offered durable bonds, producible under modern manufacturing methods; and (2) the depletion of choice timbers supplying the demand for high grade structural material.

Impetus for progress in wood gluing was also provided by the engineering advantages of glued wood products such as improved strength and dimensional properties made possible by the selection, location, and orientation of different components, and the versatility in designing unlimited sizes and shapes. Economically, many advantages ensue from the opportunity to utilize otherwise inferior species in non-critical parts of the construction.

Encompasses Three Fields

Despite a high level of engineering that glued wood products and processes have attained, it is somewhat surprising that wood gluing remains more an art than a science. One of the reasons for this situation is that wood gluing encompasses at least three major fields of knowledge, viz., chemistry, engineering, and wood technology. The advances of the art have been made principally through the empirical efforts of chemists and engineers, while wood technologists have participated to a considerably lesser degree.

It has become increasingly evident that the scientific status of wood gluing, and the speed of further progress are dependent as much upon increased information about wood, its surface characteristics, and its interaction with the properties of the adhesive, as upon improvements in the chemical composition of adhesives and the mechanics of their application.

Wood gluing as a process may be considered fairly simple in comparison to the gluing of such materials as metal, glass, and plastics. Wood is a porous, cellulosic material having great affinity for water and other polar liquids, and it therefore should present a favorable surface for bonding with a large number of adhesives.

The formation of a bond between two wood surfaces can be reduced to several basic functions of: (1) applying the adhesive, usually in liquid form, to one surface; (2) bringing the mating surface into contact; and (3) applying pressure until the adhesive hardens. Hardening of the adhesive is usually accomplished by loss of solvent into the wood and/or by polymerization with the aid of catalysts or heat.

It would seem that almost any fluid resinous material possessing the property of hardening to a solid state could serve as a wood adhesive. This is far from the actual situation. Had it been true, the number of available wood adhesives would be increasing almost daily.

In addition to the property of hardening, adhesives must also possess correct chemical and rheological properties (physical behavior) during and after curing in order to perform properly. The rheological properties of the adhesive are strongly affected by the wood and the manner in which the gluing operation is carried on. Wood varies in porosity and in absorbency. Their effects on the adhesive are in turn affected by the thickness and cut of the laminations, and compounded by the assembly and curing conditions employed. Frequently all these variations exist in the same construction and it is apparent that an adhesive must have substantial tolerance to such conditions in order to be widely usable. Wood is moreover capable of developing enormous stresses induced by moisture content changes, and these must be withstood by the adhesive bond.

Factors introduced by different gluing operations also affect the performance of the adhesive and must be taken into account in developing an adhesive for an operation or adapting an operation to an adhesive. Elements of variation include the construction, preparation of the wood as to surface and moisture content, manner of applying the adhesive and assembling the construction, pressure devices, means of heating, and quality of the personnel and equipment.

The source of many innovations is adaptation; making slight changes in formulation or procedure to enhance the bond-forming situation under these varying conditions. As will be shown later, the majority of recent developments may be classified as simple adaptations of previously successful operations.

Gluing Trends

In the development of wood adhesives, three characteristics which are usually the chief considerations in the selection of a glue by a buyer: cost, handling properties, and durability, have greatly influenced past trends

[1] Based on information furnished by members of the FPRS Glues and Gluing Committee.

[2] Committee members are: C. F. VanEpps, Jac Tigelaar, H. E. Worth, P. H. McCormack, R. F. Blomquist, J. L. Butler, E. S. Harrar, C. F. MacLagen, R. Williams, B. S. Bryant, D. B. Richards, Thomas Cook, and Charles Hemming.

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of development and will undoubtedly have a bearing on future developments. These features often go hand in hand.

Briefly, the trend of development was from glues of plant and animal origin to synthetic resin adhesives; from glues of low durability to those of extremely high durability, more permanent than the wood itself. It should be stated, however, that in speaking of a trend of development, the sense of a sequence of innovations is chiefly implied in which a particular property may have been improved. Some of the properties occurring in the earlier natural adhesives have never been surpassed, and many present gluing operations profit by their use. The salient features of the natural adhesives, animal, starch, soybean, and casein, are too well known to require mention. Each possesses its own combination of properties which distinguishes it from the rest.

In the earlier stages of development, great durability could be obtained only through the use of high temperatures. This limited durable glued constructions to thin plywood which could be readily heated from the platens of a hot press. Gradually, adhesive researchers were able to reduce the curing temperature until durable bonds could be made at room temperature. These glues, however, were expensive and a competitive trend set in to reduce their cost. At the same time, trends were evident leading to the improvement in durability of the older starch and protein glues. This was done by the use of additives such as formaldehyde and resins.

Types of Adhesives

Of the synthetic resins that have been found suitable as wood adhesives, polyvinyl acetate and the formaldehyde polymers of phenol, resorcinol, melamine, and urea, have been most commonly used. Phenol is considered the grandfather of the synthetic resins and is still today the standard of durability against which all other adhesives are compared. It is used principally in the manufacture of plywood where heat can be introduced to effect the cure. A major distinction from the other resins mentioned is phenol's highly alkaline nature, which contributes to the excellent wetting properties which it shows toward wood. It is characteristically dark red in color.

Phenol formulations are also available with acid catalysts and these can be cured at room temperature. The question of damage to the wood by the action of the acid catalyst has not been fully answered although successful operations are reported. Considerable evolution may be observed within the phenol family, beginning with the familiar Tego film glue, to alcohol soluble, and finally to water-soluble resins. The latter in a low state of polymerization are also used for impregnation of wood in the manufacture of impreg and compreg.

Resorcinol resins are similar to phenols in color and in chemical type. Since resorcinols are much more reactive than phenol, they cure at room temperature in nearly neutral medium. They are formulated and sold with a deficiency of formaldehyde in order to prolong the shelf-life. At the time of use, paraformaldehyde is added as hardener, after which the mixture remains usable three to four hours, depending upon the temperature.

Resorcinols are among the most expensive wood adhesives but, when *fully* cured, are as durable as phenolics. One of their chief advantages lies in permitting the construction of massive assemblies which are difficult to heat but which must see service under severe exposure. It has been found, however, that the ultimate in durability is not achieved unless some heat is introduced for a period of time, depending upon the construction and the species.

Melamine and urea resins are chemically different from phenols and resorcinols, being derived from amine type compounds. They both produce colorless bonds and cure with acid salt catalysts.

Straight melamine resins are intermediate in cost between phenols and resorcinols and also require an intermediate temperature for curing. Bonds made with straight melamine resin appear to be comparable in durability with those of phenol and resorcinol, although some recent evidence indicates that melamine may be somewhat less resistant to prolonged exposures at elevated temperatures. This resin affords an opportunity of forming a colorless bond of high durability.

Urea resins further reduce the disadvantages of cost or color of the resins previously mentioned. They may be cured either with or without heat, and may be used straight or extended with flour. When used straight, urea resins withstand considerable soaking in water at room temperature. However, they tend to lose strength under high moisture and temperature conditions.

Polyvinyl acetate resins are again different from all the rest in that they are emulsions in water, and develop strength by loss of the water to the wood. They do not depend on heat or catalysts for curing, they are colorless, and they possess excellent adhesion qualities. An outstanding advantage is that they arrive in the glue room ready to use. No mixing is necessary and they develop joint strength rapidly; hence they are favored in assembly work. These resins have shown such promise in woodworking that many improvements in water and heat resistance, and in plastic flow properties have been made since their inception.

Successful Improvements

Many variations exist among wood adhesives, but a noteworthy fact remains that no single one possesses all the desired characteristics for universal usage. Numerous attempts have therefore been made to combine or otherwise improve wood adhesives, but this has often resulted in exchange rather than change of properties. One of the early successes was the combination of melamine and urea. This improved the durability of urea proportionately to the percentage of melamine added, but did not reduce the curing temperature required for melamine.

Resorcinol and phenol have also been combined, apparently without serious loss of curing advantage of the resorcinol. The combination of phenol and soybean established an important intermediate level of durability. Improvement in polyvinyl adhesives was sought by copolymerization and by mixing with urea resins, thus combining the fast set of the one with the greater resistance of the other. Interest in the polyvinyl-urea combination appears to be gaining rapidly and increasing promotion is foreseen for the near future.

Urea resins have also been modified with latex and with furfuryl alcohol, the former to impart faster clamping times and provide some flexibility to the bond, and the latter to reduce the shrinkage of the cured adhesive and thus improve its gap-filling properties. Furfuryl alcohol also tends to improve the wetting properties of the adhesive as well.

Although many such combinations exist among wood adhesives, the seed for future trends remains—more attempts to combine properties. Still needed is a glue combining the durability of a phenolic with the handling properties of polyvinyl and the cost of starch.

New Equipment and Methods

Developments in adhesives are usually paralleled by developments in the equipment and process field. These were inaugurated by the hot plate press which brought the manufacture of plywood to mass production status. Other innovations which followed included:

Electronic heating brought the advantages of the more durable resin adhesives to heavy constructions, and

reduced clamping time to a matter of seconds. Bag molding in huge autoclaves made possible the forming of plywood to complex shapes and resulted in such spectacular articles as the PT boat and the Mosquito Bomber. The combination of wood and resin under heat and high pressure led to the development of a new material, compreg, embodying the characteristics of both.

One process which has stirred the imagination of all who work with wood is the formation of large panels from wood waste and low grade timber. The wood is reduced to chip size and subsequently pressed into panels using resin binders, chiefly urea or phenol, and high heat and temperature.

The lamination of large curved rafters, beams and arches for the construction of barns, gymnasiums, and hangars which require clear floor space, and the lamination of entire ship keels of mine-sweeper size, are achievements of modern wood gluing. At the present time, laminating is being carried one step further. Since some adhesives are more durable than some woods in certain service conditions, it has been found desirable to treat the wood with preservatives before gluing. The successful gluing of wood treated with certain preservatives, when the appropriate bonding technique is used, broadens immeasurably the frontiers of wood utilization.

Industry Developments

Against this background of development, the adhesive industry is found in a highly competitive situation. Such a situation bodes well for the adhesive users because it should result in continuous improvement at lowest prices. It is interesting to note that prices of wood adhesives have remained fairly steady during the time when the costs of other products have spiralled upward. This situation can have undesirable as well as desirable aspects, however, since in reducing profit margins, the amount of long-range fundamental research that can be supported as a basis for future progress, technical assistance to customers, and application research, also tend to be curtailed. Nevertheless, some significant changes have occurred in the past few years, and it appears these trends will continue.

One of the important trends is a reduction in the number of different adhesive formulations of the same chemical type produced by each supplier. Previously it was considered good customer relations to have a formula exactly tailored to a particular operation. This led to the manufacture of hundreds of variously coded formulations, and inevitably caused confusion among users. In many instances, it has been found feasible to replace these by a relatively few basic formulations. Specific adaptation then is done on the job with the use of an array of catalysts. The extreme versatility of urea formaldehyde adhesives, for example, is thus fully utilized. An adhesive user may carry an inventory of a single resin and by choosing suitable catalysts, use it for hot or cold pressing, extend it with flour, or fortify it to obtain a high degree of durability.

While the number of formulations within each type of adhesive was reduced, many manufacturers now carry more different types in an effort to give a complete service to their customers. A complete line may include phenol, resorcinol, urea, melamine, polyvinyl, and sometimes casein, soybean, and starch.

Shipping and Storage

In the interests of reducing costs to the customer, two further developments may be mentioned. For those users who normally add extenders to urea resin mixes, low solids content liquid resins are available which are easier and cheaper to produce because evaporation under vacuum is not necessary. Usually water must be added with flour to obtain the proper consistency, and it appears logical to avoid the expensive evaporation step. While this means freight charges on more water, it has been cheaper to ship water than to evaporate it. The success of this innovation, however, depended to some extent upon another, i.e., bulk shipment, storage, and handling of the resin solution. Those who benefit most from low solids solutions are the large volume users. They purchase in tank car quantities, pump it into storage tanks and from there to the glue room. Freight and handling costs are thus reduced to a minimum.

These later developments led to questions regarding the actual amount of resin solids contained in the solution purchased. Consumers wished to know how much resin and how much water they were paying for. Since methods for determining solids content gave variable results, greater promotion of "neat" resins, that is, resins in dry powder form without fillers or other added materials occurred. The purchaser then could mix the complete formulation himself.

Perhaps one of the most significant trends, and one that can have far-reaching results, is the increasing awareness of the necessity for basic research in the field of adhesion and measurement. Much information is needed on colloidal characteristics of wood, nature of wood surfaces both interior and exterior, glueability of wood as affected by certain treatments, and the actual relationship between wood and adhesive and how this relationship may be observed in test specimens.

Information is also needed on machining wood to produce the best surfaces for gluing, particularly tolerances and specifications for controlling this factor in gluing operations. Many improvements in the gluing process can be achieved through better understanding of the materials involved.

Summarizing the above, innovations in the field of wood gluing may come from many directions: new glues or modification of old glues, new catalyst systems, new means of applying heat, new equipment, different constructions, new methods of processing stock, or new means of evaluating performance. A few of these which have occurred in the recent past have been reported by the members of this Subject Matter Committee at the annual meetings.

In the area of adhesives, polyvinyl acetate is now available in powder form. It is also being prepared in alkaline solution to improve bonding properties. A number of new adhesives have been marketed for bonding metal to wood, wood to rubber, and hardboard to wood. The latter includes a high solids resin which is reported to improve the quality of the bond obtained under production conditions. New approaches were reported in the development of craze-resistant urea resins. Two new extenders for resin glues are being used, Borifil and Silvicon. Contact glues having a neoprene base are frequently used in the bonding of high pressure laminates to plywood or particle board. They require no clamping since a bond forms upon contact of the two surfaces.

Tape gluing, especially in the wood to metal field, also promises many advantages from the standpoint of handling. An unusual resin, epoxy resin, is finding increasing usage in the wood gluing fields. Its chief characteristic is that it is a clear liquid containing 100% solids, in other words, carries no solvent. Based upon ethylene oxide type derivatives, they are very low in shrinkage, and adhere well to metal, plastic, and many other materials.

The technique of applying adhesives has received some attention. In the gluing of hardboard or high pressure laminates with cold-setting adhesives, poor bonds sometimes result. It is suggested that gluing be preceded by scuff sanding to ensure a suitable surface, followed by the use of casein, polyvinyl acetate, furfuryl-modified urea or animal glue. In some cases of hardboard gluing, presizing may be found beneficial.

Most glue users appear to be satisfied with present rubber-covered roll spreaders for applying glue in veneering work. However, in assembly gluing there appears to be a trend away from brush and stick application toward mechanical applicators which deposit glue in the exact amounts and at the precise points desired. This is an attempt to reduce waste glue and waste motion, and yet ensure properly filled joints. Oil cans and "squeeze bottles" with suitable spouts are more and more appearing at work benches. The logical end-point of this trend is a central glue pot with feed lines to the assembly benches, and depositing the glue in the joints through specially designed nozzles and wing tips.

Among the new glued products to make their appearance, the following have rapidly become commonplace: laminated shoe lasts. laminated baseball bats and bowling pins, bows and arrows, chipboards, hardboard-plywood combinations, paper cores, aluminum foil to veneer in the production of cigarette proof surfaces; and aluminum sheet to hardboard. Much work has been done in butt joints, scarf joints, and end-to-side-grain joints, and higher strengths are obtainable than commonly thought.

Evaluating Glue Bonds

Important activity has occurred in the area of testing or otherwise evaluating bonds. The following is taken from a report to the committee by Dr. R. F. Blomquist, USFPL.

In the development of new glues and new glued products, the improvement of methods for evaluating such products is an important factor. Such improvements have been receiving considerable attention in various laboratories. The work may be logically divided into two principal groups of interest. These are methods of determining the initial strength characteristics of the joint, and methods of determining the durabilty of glue joints.

Initial test methods include a number of mechanical test methods, some of which are very simple and some of which would require rather elaborate test equipment and therefore are of interest primarily as research tools. It should be emphasized that although the most adequate numerical test data can be developed when tests are made under carefully controlled conditions on standard testing machinery, there is a considerable amount of valuable information which can be obtained by the glue user in furniture plants and plywood mills by merely breaking open representative joints from his production line by the use of crude hammer and chisel or knife tests and observing the nature and amount of wood failure produced. In such tests, of course, it is important to standardize on the method of breaking the joint taking particular attention to be sure that the knife or chisel is inserted directly at the edge of the glue joint so that an adequate test of the glue joint and not of the wood some distance from the joint is obtained.

While much information has been developed in the past on shear strength of adhesive bonds, interest is increasing to investigate other strength properties such as impact strength of adhesive bonded joints of wood, particularly at lower temperatures. The method has been described by ASTM and designated D950–52T. There is also some considerable interest in tension tests and in peel and creep tests for wood bonding adhesives, particularly of the more plastic types. Test procedures have not been adequately standardized for such tests. Creep tests have been made by deadloading either plywood shear specimens or simple lap type specimens of wood bonded with the grain in the two pieces parallel. In addition, some new test methods or modifications of present test methods and test specimens are required for evaluation of the quality of bonds between wood and other wood base materials such as hardboards, fiberboards, and wood base and paper base plastics.

The problem of determining the durability of adhesive bonds in wood construction is a very important one, particularly with respect to the more durable types of adhesives which are now available for bonding wood for severe service. One of the most widely used tests at the present time appears to be the vacuum-pressure cycle test for estimating the durability of bonded joints in laminated type construction when prepared with glues of known durability such as the phenol and resorcinol types. This method is described by ASTM as D1101–50T and involves a 12-day series of 3-cycle tests, each involving vacuum-pressure soaking and drying under controlled forced air conditions. At the present time considerable effort is being exerted to shorten this period below the 12 days in order to expedite the obtaining of test results. This test has been found to be very desirable and satisfactory for evaluating the resistance of the glue joints in laminated timbers to the swelling and shrinkage stresses, and the resultant dimensional changes as a result of outdoor exposure over long periods of time.

There is considerable interest in the development of more adequate methods of rapidly evaluating the performance of adhesive bonds in plywood type construction. One of the more promising types of tests that are currently being investigated are long-term boiling and various repeated boil-cycle tests which have improvements over the conventional boil tests now included in commercial standards for hardwood and Douglas-fir plywood. These tests are of particular interest in comparing the relative durability of urea resins, melamine resins, and various combinations of these two resins.

Present Studies

Research in wood bonding is being carried on by many organizations. Subjects under investigation include development of new test procedures such as cleavage, tension, impact, delamination, gap-filling, non-destructive test, stress distribution in joints, surface properties, gluing of dissimilar materials, correlation of test results, effects of additives, quality control methods, and statistical treatment.

On the whole it would appear that substantial progress is being made in the field of wood gluing. By observing the rise and development of trends, it is possible to chart the course of progress and obtain some small insight as to where the ball is rolling. For those who wish to pursue the subject of wood gluing further, a bibliography is being prepared of the more important source materials evolved during the past 20 years.

Forest Products Education Is Everybody's Problem

A. J. PANSHIN
Chairman, FPRS Industry–Education Committee[1]

Recruiting and training technical personnel is a mutual problem of forest products industries and educators. The FPRS Industry–Education Committee is proposing a booklet to attempt to interest students in wood technology careers, and is evaluating curricula now offered. The active participation of industry is needed to carry out the Committee's objectives.

WITH EVERY PASSING YEAR we are witnessing a growing awareness on the part of the forest products industries that for an industry to remain in a competitive position, there must be greater emphasis on research in terms of development of new products and techniques, and improvement in methods of conversion and distribution. Furthermore, unless the results of this research are translated into an action program, they mean little to an industry that is trying to stay ahead of competition. The inescapable corollary of this is that success in implementing new ideas depends to a large extent on the availability of properly trained technical and production personnel.

The still unsolved problem is where can this personnel be recruited? To answer this question we must first determine the kind of technical personnel industry wants. Should they be engineers, chemists, wood technologists, business administration graduates, or perhaps all of these things? Whatever the answer, the cold fact is that today a college-trained person is a competitive commodity. The universities are being treated to the unusual spectacle of personnel managers beating paths to the doors of the university employment offices, wining and dining prospective employees, and in general acting as if college graduates were persons worth cultivating on the chance that among them may be those who can help their industry to get ahead.

It is true, of course, that among these personnel people making the rounds of the universities there are not many from the forest products industries. But neither are there many prospective employees among the college graduates who have the training that would justify their employment by, or who may be interested in accepting a job with a wood using industry. In fact, there are so few of them that they are seldom found in the general pool of college graduates available to other industries.

From the standpoint of these few it is not a bad situation because, as always under the free system of enterprise, brisk competition results in higher prices. But, looking ahead, how will this solve the problem that our industry is facing? To paraphrase C. D. Dosker, "To survive, an industry must grow. If it is to grow, it must progress". Experience of other industries shows that the most important ingredients of progress are people. So we are back to our starting point. Where will the forest products industries recruit the much needed technical personnel?

Mutual Problem

The Industry—Education Committee of the Forest Products Research Society has attempted to provide the answer. The problem will not be solved by pirating personnel from the colleges or from other segments of industry. Neither could adequate personnel be recruited from other occupations. Again, it is the case of competition plus the fact that in many instances the training and experience of these people are not altogether adequate to meet the occupational demands of the forest products industries.

The solution, therefore, seems to be for the industry to take an active part in selling ambitious young men, still in high schools or in colleges, on the advantages of technical, production and selling occupations in the forest products industries. Somehow industry itself must find the means of presenting to the youth of this nation its own story in a form that will attract them into college programs designed for training wood technologists and other forest products specialists. At the same time the forest products industries should also take an active part in working with the educational institutions in developing programs of instruction suitable for training the type of people they want.

Interestingly enough, this could be accomplished without great expenditures of money. The FPRS Industry–Education Committee proposes that, as a starter at least, it should prepare a factual booklet that will present to young people the requirements for training and the work opportunities in the various phases of the forest products industry. This booklet could then be widely disseminated by local organizations and industries in their own home towns to the high school graduates of college caliber and to the college students who, perhaps, have not yet made up their minds or who could be prevailed upon to change their programs.

Dr. F. F. Wangaard of the Yale School of Forestry, Dr. H. B. McKean of Potlatch Forests, Inc., and Fred W Gottschalk of Mackintosh and Truman, Inc., are cooperating in the task of preparing this publication. It is to be hoped that industry will lend its support in developing this pamphlet and in making its publication and distribution possible.

Surveying Graduates

The Committee has also asked Professor Everett Ellis of the University of Idaho to canvass working wood technologists, graduates of the various forest products and technology curricula, about their reactions to the curricula they followed while in school, in the light of their experience in obtaining and holdng jobs with the forest products industries. It is expected that this survey, and the constructive suggestions that may come from this group, may assist materially in evaluating the specific courses as well as the curricula now offered by the schools.

To emphasize that the problem of recruiting and training technical personnel is of mutual interest, the FPRS Education Committee changed its name to Industry—Education Committee. It is hoped that this implied concept of mutual responsibility will become a reality through active participation of industry in carrying out the objectives set up by the Committee.

[1] Committee members are: J. S. Bethel, F. W. Gottschalk, H. B. McKean, H. O. Fleischer, N. V. Poletika, F. F. Wangaard, E. Ellis, H. C. Moser, and C. F. VanEpps.

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Advances in the Field of Wood Preservation in the United States in 1954-55[1]

IRA HATFIELD
Chairman, FPRS Wood Preservation Committee

Summarizes progress made in wood preservation field during the past year. Discussed are increased use of preservative-treated wood, growing public consciousness of value of treated wood, new products and treating techniques, special research projects, new uses for treated wood, and wood preserving association activities.

WOOD PRESERVATION is an old art and its ramifications are great. Thus it is not an easy task to segregate the old from the new, or to find all of the new items that should receive recognition. If there are any omissions, they were certainly unintentional and the Committee would welcome having them called to its attention so that they can become a part of next year's annual report.

Progress for Year

In order to summarize the wood preservation advances for the past year, certain questions will be asked and an attempt made to answer them. If advances were made, a logical question would be:

Did the use of preserved wood grow in the past year?

In the preliminary report prepared by Merrick (13)[2] in cooperation with the American Wood-Preservers' Association, these paragraphs appear in the Foreword:

"The following statistics are compiled from reports of 277 of the 302 known wood-treating plants and are estimated to include more than 95 per cent of the output of the wood preservation industry in 1954. The statistics are preliminary and show the activities of the reporting plants only, with no estimate for the 18 pressure and 6 non-pressure plants which have not yet reported. A complete and more detailed report will be issued later.

"Reports to date for 1954 indicate that cubic footage of material treated was about 16 per cent less than in 1953. Decreases are shown for all materials except fence posts, which showed a slight increase in numbers treated. Based on cubic footage, treatment of crossties decreased about 18 per cent, poles 14 per cent and lumber and timbers 12 per cent."

Does this mean that wood preservation is on the decrease, or how should one interpret these facts? The railroads, for instance, curtailed treated tie procurements in the early part of the period covered by this report, and that fact was reflected in reduced treating volume. Although there was some decrease in the use of treated poles, crossties, switch ties, and other items treated by the pressure and hot-cold methods in 1954, there is indication that the overall use of wood preservatives did not decrease as much as indicated by the Merrick report. The figures given by Merrick are for plants using methods covered by the American Wood-Preservers' Association standards (pressure and hot-cold treatments) and do not include preservatives used by the millwork industry or materials sold over the counter.

Use of preservatives by "non-standard" methods undoubtedly increased, and although this may be taken as an ill omen by pressure treaters, the following facts should be borne in mind. In the 100 years of wood preservation in the United States, the bulk of the treated wood has been used by the communications industries such as the railroads, telephone, telegraph, and electrical companies. Yet they consume only a fraction of the wood utilized as round or saw-timber. We are just entering the age where an ever growing segment of "private" consumers is becoming interested in wood preservation. Problems of supplying small quantities of pressure treated wood have not been solved, and the public is not to be denied some wood protection even if it is not the best. This has meant that posts, poles, timbers, lumber, and millwork items have been given an immersion treatment, often because small quantities of treated items were not sufficiently available at a cost that would allow the treated wood to compete with steel or other materials. If wood was to compete, the user had to use locally available wood with a low additional cost for treatment.

It is interesting to note that one State Experiment Station reported that whereas at one time farmers thought they should treat their own fence posts by the steeping process, the Station now had little call for demonstrations of home application of preservatives. The farmers preferred to buy pressure-treated posts rather than bother to treat their own. Such a condition is desirable, but will exist only if pressure-treated posts are stocked by lumber yards and farm supply stores, only if the farmer has sufficient cash income to make the purchase, and only if the price of pressure treated items is competitive with other items *in proportion to value received*. By that we mean that treated wood does have plus values over competitive items, but those plus features must be sold.

It is true that as more and more treated poles and ties go into service, it tends to reduce the treating potential for these items, but there is a big field of wood preservation still available, and the farsighted treating company will develop technical, sales and advertising facilities to make it possible for them to go after this new business. Unless they do, they cannot expect to operate at near capacity even in good economic periods.

Public Awareness of Value

Is the public more conscious of the advantages of using preserved wood or wood preservatives?

The answer is divided into three parts by differentiating what is meant by "the public." For ease of presentation, the public may be defined as the individual householder or do-it-yourself person; the building industry, public utilities, and other interested groups to illustrate industry; and government,

[1] This report is based on information furnished by members of the FPRS Wood Preservation Committee. Members are: M. S. Hudson, J. A. Greenwald, Jr., G. G. Garlick, P. B. Mayfield, Ralph Van Allen, J. O. Blew, F. J. Meyer, R. A. Zabel, H. W. Hicock, C. S. Walters, E. A. Behr, M. Lehrbas, W. Buehler, L. A. Mueller, I. V. Anderson, R. D. Graham, J. N. Roche, and G. G. Marra.

[2] Numbers in parentheses refer to literature cited.

The Author: Ira Hatfield holds A.B. from Simpson College, M.S. from Colorado Agricultural College, took advanced work at U. of Wisconsin. He was employed by the U.S.D.A. Bureau of Plant Industry from 1929–36, plant pathologist with Monsanto Chemical Co. 1936–46, co-owner of Planetary Chemical Co. 1946–49, and has been Manager, Industrial Preservatives Section, Monsanto Chemical Co., St. Louis, Mo., since 1949.

referring to State and Federal Agencies such as State Highway Departments, State Institutions, U. S. Forest Service, Federal Housing Administration, Veteran's Administration, and various military agencies.

Statistics are not readily available on the amount of wood preservatives sold over-the-counter for the past few years, but there is growing evidence that sales of this type of treating material have been on the increase. The addition of oil-borne preservatives to the oil (creosote) and water-soluble type preservatives has increased the scope of materials available to individual users, and has helped increase over-the-counter sales. Treating plants or lumber yards have not been able to advertise that you can get a treated "stick or a carload", so the home owner either has to treat his own back steps, picket fence, child's sandbox, or clothes line post, or leave them to the mercy of decay or termites.

It is only occasionally that a salesman oversells the merits of wood preservatives applied by "home methods", but both the salesman and home owner can honestly say that the use of preservatives usually extends the life of the wood sufficiently to be worth the effort and money expended. There are many evidences that from these small beginnings, interest develops in better treatments and that home owners finally try to procure pressure treated wood.

Industry is more cognizant of the value of using treated wood than ever before. Architects, engineers, purchasing agents, and maintenance men are investigating the merits of preserved wood in a manner hitherto unknown. As the Service Bureau of the A.W.P.A. put it, "people are hungry for information on treated wood." And that stimulates us to add that the efforts being made by the A.W.P.A. Service Bureau to help people know the merits of treated wood have played a significant role in the past year in bringing about this public consciousness. Likewise, probably in no previous year have the wood treaters and the manufacturers of preservatives done such an extensive job of public education advertising as in the year just past.

Government Use Growing

The gain in the field of wood preservation consciousness for State and Federal agencies has also been gratifying, although not all groups are completely aroused. Both the wood producing industry as well as the treating industry napped while competitive products drove great wedges into the wood-use field. Sometimes supplementary or replacement materials were economically justified, but it is now being realized that design, availability, and aggressive educational campaigns can gain back lost ground and open new fields for treated wood.

Perhaps the report of the FPRS Wood Preservative Committee next year can tell of progress on the use of preserved wood in highway construction and maintenance. Perhaps it will be able to show gains in the specification of treated wood for F.H.A. and V.A. financed homes. Some progress has been made with such groups this year, but they are not fully aroused to the potential savings to be realized by the use of properly protected wood.

Many military agencies are to be congratulated on their progressive and aggressive pursuit this year of ways to save money by utilizing wood preservatives. The U. S. Corps of Engineers have supported research on the utilization of wood preservatives for military items, and they have diligently studied where economies can be made in the use of treated wood. Application of their findings can do much to conserve wood items in peace as well as war, and will be reflected in dollar savings. This should surely interest the public. The spotlight for achievement should also be shared by the Navy and other military groups who have sponsored research and in many cases have taken advantage of the use of treated wood.

Highway departments have also been re-evaluating the economies to be attained by using treated wood. The ground-work has been laid this year for more intensive studies on pre-fabricated treated bridges, and highway departments are reconsidering the use of treated wood posts, guard rails, sign posts, and other items.

A paper by Blew (5) indicated the figures for the Forest Service Properties that involve the use of wood. It is interesting to note, for instance, that the Forest Service has 50,438 miles of telephone line. Possibly the poles in these lines are not set as close as in the lines of the Bell System, but Bell (11) has 560,000 miles of line (20,000,000 poles). If one adds the pole-miles for independent lines, for Rural Telephone Administration, etc., the figure is sizable and indicates a good potential for treated poles.

We could go down the list of Forest Service wood items and find that the various governmental agencies have similar items and use a tremendous qauntity of wood. Whether the treating industry is getting its full share of the treating business represented is not known to this committee at this time.

New Products

Were new wood preserving chemicals introduced?

No new wood preservatives were introduced commercially in the United States in the year 1954–55. Because of publicity in early 1954 that thiophene oil produced in France protected wood against termites and micro-organisms, were easier to apply than most other preservatives, imparted water repellency to wood, and were relatively non-irritating to the skin, some interest in them was generated in the United States. The U. S. Forest Products Laboratory initiated limited evaluation studies but no reports have beeen issued yet. Further work will hinge on the results of these first tests and on price. Synthetic products produced in the United States leveled at about $2 per pound (2).

The company[3] importing thiophenes into the United States wrote: "We import from France, a single-distilled and two fractions of thiophenes. The single-distilled fraction has a boiling point between 120° C. and 500° C. The heavy fraction will undoubtedly contain hexylthiophenes and other similar products. We believe the average molecular weight of the side chain will be about 8 carbon atoms." Speaking of the heavy fraction, the letter said: "The product sells for $0.60 a pound in 55-gallon non-returnable drums."

Another group of products that received attention was the organo-tin compounds. Van Der Kerk and Luijten (16) wrote: "From these experiments and from corresponding tests with other types of wood preservatives, it would appear that organo-tin compounds of the type mentioned are likely to belong to the most active wood preservatives known at present." Interest was stimulated in the organo-tin products in the United States until it was learned that the products have a high mammalian toxicity. Because low mammalian toxicity is one of the desirable qualities of a wood preservative and the organo-tin compounds did not possess this quality, interest has waned in these compounds as wood preservatives.

Another chemical group that has been actively considered in Europe is composed of the chlorinated naphthalenes. The lower chlorinated products are generally not suited for wood preservation because of their physical and chemical characteristics, and the higher chlorinated products also have not been popularized in the United States because of their toxicological effects. During the past year it was definitely established that the higher chlorinated naphthalenes caused hyper-

[3] Private correspondence.

keratosis (X-disease) of cattle (3), and these findings would seriously retard consideration of these products as wood preservatives even if they were effective against decay or wood-destroying insects.

Research in Treating Methods

Were new treating techniques introduced?

Although research is continuing on different techniques for drying wood and recovering the solvents used as carriers for wood treating chemicals, no new techniques have come to our attention.

At least three groups are carrying on studies on vapor drying, solvent seasoning, or the solvent recovery process. Although there are variations in these approaches, each seeks to reduce degrade during the removal of moisture from the wood and, where preservatives are added, to get a more thorough treatment of the wood but reduce the absorption gradient that occurs from the outside to the inside of wood as is the case with wood treated by conventional pressure methods.

A second advantage sought is to reduce bleeding from the treated wood. In the case of non-colored solutions, it is hoped that these accomplishments will make the wood more finishable and in a shorter time after treatment.

There has been increased interest in the vacuum process for the treatment of small items such as millwork and other items used by the building industry. Companies that have installed vacuum treating equipment point out the value of the elimination of the "drip and drain" phases that were a part of immersion treatments, and indicate that they get a more uniform distribution and retention of preservative than with the immersion process. Papers describing such equipment appeared in 1952 and 1953. (4) (15).

Closely associated with wood preservation has been the study of equipment to incise Eastern hardwood ties and to full-length incise pole species such as larch. Both of these studies are aimed at better treating to reduce checking. Studies on the dowelling of ties to reduce checking has also continued.

Testing Techniques

What special studies of value to the art of wood preservation were carried on?

The problem of how to evaluate a wood preservative without waiting 50 years for service records has long been a puzzler. In 1952, several wood preserving companies and several chemical manufacturers set up a cooperative study at the U. S. Forest Products Laboratory, Madison, Wisconsin. The immediate purpose was "to develop an accelerated laboratory test method for determining the effectiveness of wood preservative materials."

In April 1955, the Laboratory presented to the cooperators a "Preliminary Outline of a Proposed Method for the Laboratory Evaluation of Wood Preservatives." It is based on a soil-block test method, and details of the method are sufficiently worked out so that the A.W.P.A., A.S.T.M., National Woodwork Manufacturers Association, and other groups can use the preliminary outline to develop a standard method. This work illustrates what the pooling of resouces can do toward accomplishing what one or two companies could not afford to do.

In field testing, an accomplishment for the year was the recommendation of A.W.P.A. Committee P–6, Methods for the Evaluation of Wood Preservatives, that the "Standard method for field testing with stakes, which has been held in a tentative status for several years by the A.W.P.A., be confirmed as a full standard method." The motion passed at the Convention; it now awaits confirmation by letter ballot.

Research Reports

Among papers on laboratory studies to evaluate chemical compositions as wood preservatives, the eighth in a series of papers has been issued from the U. S. Forest Products Laboratory by Duncan (6) and her associates. Outstanding contributions were also made on identifying the components in mixtues of creosote and petroleum. Heiks et al (8) added another paper on this subject to those given in 1952 and 1953, and Stasse (14) reported on development of the 5-ball column method for the distillation of creosote-petroleum mixtures as a means of simply and rapidly studying admixtures of this nature. Other studies on creosote and creosote treatments were presented at the 1955 A.W.P.A. Convention and these papers will appear in the 1955 Proceedings of that Association.

Still another active project in the field of research on wood preservatives was the search for more simple and accurate methods of qualitatively and quantitatively determining the amount of given wood preserving chemicals in treating solutions and in treated wood. A paper by Hudson (9) describes and illustrates "a quick and reliable method of test for determining the amount of creosote in poles. The test can be run in the field by any lineman"—by use of a chemical kit.

New tests for pentachlorophenol have also been extensively studied. At least one technical group[4] has been studying the use of an auxiliary solvent (methyl alcohol) to complete the extraction of pentachlorophenol from wood after an initial extraction with toluene. Although toluene seems to do a good job of extraction of Penta from freshly treated wood, the added extraction seems to be necessary for wood that has been treated for some time. The temperatures to which the wood may have been subjected also seems to "fix" the Penta in the wood and make extraction more difficult.

In March 1955, a 33-page technical bulletin was issued containing information both as to methods of extracting Penta from different media and on methods of qualitatively and quantitatively determining the amount of Penta present (1).

The Service Bureau of the A.W.P.A. is sponsoring a research project at the U.S. Forest Products Laboratory to compare the depths of penetration obtained with pressure treatment as compared with those obtained with some of the non-pressure treatements. Three types of preservatives (creasote, 5% Penta solution and chromated zinc chloride) are being used in the test which includes two different woods (Southern yellow pine and Douglas-fir) and two stages of seasoning—unseasoned and air dried.

Data given in the Bulletin by Hicock and Olson (7) indicated quite clearly that there is a redistribution of salt (zinc chloride) within a round post *after* the initial intake of the solution and *during* the seasoning period. Their observations plus that of other research workers indicate that the success or failure of a treatment may be closely correlated with this translocation of chemical.

New Uses

What significant new uses for treated wood developed this year?

One significant gain for the year was in the use of small short poles for farm construction. The publicity given pole type construction by various governmental agencies as well as private industries has certainly created the demand for more poles, and practically all publicity points out the advantages of using preservative treated poles.

Another area that showed a gain was the treatment of plywood with oil-borne preservatives using solutions applied to meet the requirements of Federal Specification TT–W–571d. Intensive research on preservative, water-repellent, fire retardant formulations for use on plywood as well as other items has been carried on in the past year. It is hoped that this Com-

[4] From communications to the writer and to the Preservatives Committee of the A.W.P.A.

mittee will have more to report on such formulations at the 1956 National Meeting.

The treatment of laminated wood for truck and other automobile bodies received notice from the work done by the Timber Engineering Company on their all-wood army truck body. According to an article by McSwain (12) describing this work, new interest has been developed in getting wood back where competitive products have made telling inroads.

The questionnaire to FPRS Wood Preservation Committee members asked for information on new utilization of treated wood. One reply dealt literally with a small use, but was sufficiently interesting to quote: "We worked out a treatment for wood tunnel models for the Aeronautical Engineering Department, using a water-repellent solution. The treatment lengthened the life of the models by making them more resistant to abrasion by dust particles and by stabilizing the models dimensionally." Possibly the results obtained on these small items will indicate trends that will find commercial applications, for the volume of wood treated with preservative, water-repellent formulations is on the increase.

Organization Activities

Any new organizations formed that deal with wood preservation or any new activities of established organizations?

In May 1954, operators of pressure treating plants in the Southern area met in New Orleans, and discussed the formation of what has become the Southern Pressure Treaters Association. It held its first annual meeting in New Orleans in October 1954, with 55 in attendance. Their bulletin will carry the title *The Cylinder Door.* (The Western Wood Preserving Operators Association had been previously formed.)

A new organization is The Vacuum Wood Preservers Institute.

Activities of the Service Bureau of the A.W.P.A. have also increased. On May 21, 1954, they launched their new series of *News Letters.* These have been extremely informative on wood preservation activities, and have been valuable promotional aids. Their increased budget as well as the additional of more regional service engineers has boosted promotional efforts. The *Wood Preserving News* also has a new format and increased content. At the annual meeting of the A.W.P.A. in April 1955, the Service Bureau Secretary–Manager proposed that the A.W.P.A. Constitution and By-Laws be amended so that the name Service Bureau would be changed to the American Wood Preservers Institute.

Stimulation of research and stepped-up educational activities has also taken place in the non-pressure field. The minutes of the Eighth Annual Meeting of the Coordinated Wood Preservation Council (formerly known as the Coordinated Fence Post Preservation Investigations in the Southeast) contained reports from the 11 cooperating agencies.

Their Group Report No. 1, entitled "Cold-Soak Treatment of Fence Posts in Fuel-oil Solutions of Pentachlorophenol and Copper Naphthenate", will be useful not only to show what tests are under way, but also to indicate what to do in order to get the greatest possible useful data from this mass of work being done in scattered locations. If it should serve no other purpose, it has already shown the variations in retentions of preservatives not only between the different species of wood, but also within a specie when posts are simply immersed in treating solutions for varying lengths of time. Their service record reports on posts treated by the non-pressure process are valuable, and the Council is considering ways to make the collection of data still more valuable.

The Minutes of the Second Northeastern Wood Preservation Conference by Lockard (10) gave information on wood preservation problems and data especially as they apply to the Northeastern section of the United States.

The Preservative Standards Advisory Committee of the Preservatives Committee of the National Woodwork Manufacturers Association met in Madison, Wis., in May 1955. That group seeks to find answers on how to provide and assure good results for millwork treated at the manufacturing plants after the items have been milled to shape and size. No economically feasible methods have been developed for treating prefabricated millwork at commercial treating plants, so this group has pioneered in finding ways to produce treated wood that can provide the public with the advantages of wood and yet compete with metal and other competitive materials.

The Committee did not compile a list of the new literature pertinent to wood preservation that has appeared since the 1954 F.P.R.S. meeting, and time did not permit an exhaustive search of the literature before preparing this report. It is recommended that such a bibliography be prepared in the future. One way for the Committee to function more thoroughly in this matter in years to come is to have some system established whereby the membership can send in citations they have seen that should go into such a listing. Then the Committee can augment the references they find in abstracting or other facilities.

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Review of Chemical Utilization[1, 2]

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Discusses recent developments in the chemical utilization of wood, the most outstanding having been the growth of the pulp and paper industry. Reports on wood residue utilization, research in extractives, increased demand for charcoal, utilization of spent sulfite liquors, and developments in the chemistry of lignin.

THE MOST OUTSTANDING DEVELOPMENT in the chemical utilization of wood has been the growth of the pulp and paper industry. Three recent reports (13, 78, 80)[4] dramatize this growth and the importance of this industry to the Nation. The production of paper and paper-board in the United States in 1954 was 26.7 million tons and the sales of these products reached a peak of almost $9 billion. The paper industry now ranks fifth among the Nation's top industries in the value of shipments made. Per capita consumption of paper in 1954 was about 384 pounds. In addition, consumption is still in a rapidly growing state with no decline in sight. One reason for this is simply the increased population. Another is the increased use of paper products by the population. Still another is the development of new pulp and paper products.

This growth pattern of the industry is creating an increasing pressure for new and greater sources of fibrous raw materials. The Timber Resource Review, for example, shows the consumption of paper and paperboard to be 29 million tons for 1952, but predicts a demand in 1975 of 58 million tons and a further demand of about 95 million tons by the end of the century. The fibrous intake for the year 1952 was 17.3 million tons of new wood pulp, 7.8 million tons of waste paper, and 1.2 million tons of nonwood material to give a total of 26.3 million tons. These figures document the overwhelming importance of wood as a source of fiber.

Additional predictions of requirements for pulpwood from domestic sources are given in the following tabulation (roughwood basis):

Pulpwood species	Pulpwood needs (million cords) 1952	1975	2000
All species	25.1	42.0	76.0
Per cent	100	167	303
Softwood	21.4	32.0	52.7
Per cent	100	150	246
Hardwood	3.7	10.0	23.3
Per cent	100	270	630

Increase in Hardwood Use

Perhaps the most significant observation to be gained from these data is the tremendous increase in usage of hardwood species for pulp and paper, although the major development of the pulp and paper industry over the years in the United States has been based on softwood species. An increasing amount of research and attention has been given to the use of hardwood species during the past 25 years. The use of hardwoods has been studied simultaneously with efforts to increase the percentage yield of pulp, and fortunately, hardwood usage and high-yield pulping have gone hand in hand in their development.

Progress in the use of high-yield processes is continuing, perhaps with greater emphasis than before to offset increasing costs of pulpwood and to take full advantage of hardwood species. Of the major processes used to convert hardwoods to pulp, the neutral sulfite semichemical process now is the largest user of hardwood. Most of this pulp is consumed in unbleached products, such as corrugating board, although there is a marked increase in the development of semichemical pulps for high-quality bleached papers.

As the inherent good qualities of these pulps become more widely appreciated, their acceptance can be expected to increase greatly the number of bleached paper products for which neutral sulfite semichemical pulp is found well suited. Bleached products include bond paper, milk-carton board, foodboards, and glassine papers. Overall improvement in the status of neutral sulfite semichemical pulps is dependent not only on developments in pulping, bleaching, and cleaning of these pulps, but also on improvements in methods for recovery of spent liquors and on better methods for harvesting and barking hardwoods.

Recent investigations on the grinding of pretreated hardwoods (the chemigroundwood process) were made to determine its value as another means for utilizing hardwoods to make useful pulps, and also to provide a high yield of fiber per unit of wood. In this process, logs and bolts of wood are cooked or pressure treated with a chemical such as sodium sulfite. The resultant partial pulping and softening of the wood substance makes it possible to grind the wood to a pulp, using much less power to produce pulp of higher quality than can be obtained from the same wood without treatment.

Another method for making a very high-yield pulp is the cold soda process, in which wood chips, usually hardwood, are steeped in a solution of caustic soda at room temperature and atmospheric pressure for a time, and are then refined to a pulp by disk milling. Pulp yields in this case may be as much as 90 per cent of the weight of the wood, which is in the groundwood range. While this method is being scrutinized by technical men in a number of companies, there is not yet any significant commercial production. This process, like the neutral sulfite semichemical process, is attractive because of its high yield of pulp, its adaptability to hardwood species, and its possibilities for use in plants of minimum size.

Although a pulp of good quality can be made by simply steeping the chips in caustic, it is possible to reduce the time necessary for the caustic to penetrate the chips by hydrostatic

[1] Prepared at the request of the FPRS Chemical Utilization Committee. The committee acknowledges the contributions to this report of: A. B. Anderson, California Forest Products Laboratory; A. S. Gregory, Weyerhaeuser Timber Co.; Irwin A. Pearl, Institute of Paper Chemistry; and J. C. Pew and R. J. Seidl, U. S. Forest Products Laboratory.

[2] Members of the FPRS Chemical Utilization Committee are: Chairman R. C. Sproull, J. F. Saeman, R. W. Cairns, A. H. Vroom, A. Elmendorf, H. Schwartz, A. K. Esterer, H. B. McKean, A. B. Anderson, L. C. Wallace, W. J. Mason, E. L. Powell, D. L. Kenaga, W. R. Smith, A. Pollak, E. F. Kurth, J. Gardner, F. G. Perry, Jr., and A. S. Gregory.

[3] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[4] Numbers in parentheses refer to literature cited.

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treatment of chips. This can reduce the penetration time from, for example, 2 hours to about 10 minutes without loss of pulp strength.

A modification of caustic soda pulping involves the repeated squeezing and relaxing of wood chips in a bath of caustic to produce cold soda pulp. This results in a continuous method by which pulp can in some cases be produced from selected species of wood in a matter of seconds. This has been achieved in a continuous roller press, but presumably can be done in other devices.

One of the problems demanding attention in the cold soda process is the recovery of caustic spent liquor for re-use. Toward this end, the use of dewatering presses appears promising. They exert very high pressure on softened chips or coarse pulp and extract a large amount of liquid from the material. Spent liquor is thus available in a more concentrated form for re-use or disposal. The high mechanical pressure also gives promise of improving penetration of liquor into chips and of breaking up the softened chips into coarse pulps to prepare them for additional refining.

The mechanical breakdown of ordinary softwood chips to pulp by means of a screw press is a fairly new research and development activity. This procedure has as its objective the production of a pulp to compete with groundwood, but made from chips instead of bolts of wood. Chips, usually softwood, are wetted but not chemically treated, and are mechanically broken down in screw presses to a coarse pulp that is further refined. This pulp is characterized by good bulk, opacity, and strength in the range obtained from the grinding of wood. It is expected to be a useful pulp for such papers as newsprint.

Most of this discussion has related to the use of hardwoods because of the great future importance of hardwood as a source of pulp and, perhaps equally important, the effect of hardwood use on good forest management. The largest portion of wood pulp for many years to come will still originate in the softwoods, and appropriate steps are under way to improve the yield, use other species, and develop new sources of softwoods.

Utilizing Wood Residues

One of the most significant of these developments has been the widespread use of chips from wood residues at sawmills or other wood-consuming plants as raw material for pulping. It is estimated that kraft pulp mills in the Pacific Northwest obtain close to three-fourths of their raw material in the form of chips from sawmills and plywood plants. Although this has perhaps been a more practical and obvious thing to do in this region because of the large volumes of substance in a given location, the trend is also evident in other parts of the country, notably in the South and Southeast. Progress is being made in the establishment of concentration yards for chips from small sawmills to facilitate gathering sufficient chips at one spot to sustain a mill.

The advent of the log barkers into sawmills as well as pulp mills in order to produce chips for pulping has made available large quantities of bark. Increased interest has been shown in ways of utilizing this material. There are two large plants (15) as well as several small ones now in operation to produce a compound for use as a mud dispersant in oil-well drilling operations. One company's production alone has reached 10,000 tons per year.

Research in Extractives

The extractives in wood are of special interest. It has been shown that pinitol can be produced from sugar pine and its stumpwood (2, 3).

Jeffrey pine stumpwood has been investigated and 26 per cent of the stumps have been found to have benzene-soluble material. Over half of this extract consists of resin acids, and rosin of good quality has been produced (4).

Other work on extractives has been pointed toward the naval stores industry (17,18,40,54,83).

A recent article (79) suggests ways of converting cellulose into various chemicals and products.

Increase in Charcoal Demand

After a period when supply exceeded demand, charcoal has shown a startling increase in markets the past several years. This demand is attributed primarily to the domestic market where approximately 60 per cent of the charcoal produced is used. The annual production of charcoal in this country is approximately 400,000 tons, 65 per cent of it in 9 large plants. The remaining 35 per cent is produced in kilns that are scattered in all parts of the country. Approximately one-third of these are producing charcoal from sawmill residues. The preference by the domestic consumer appears to be for charcoal briquettes. Several new briquetting plants have come into production recently.

Last summer the demand for charcoal exceeded the supply, and as a result many small kilns holding from 1 to 25 cords of wood have been built or are planned. This type of operation with the kilns located close to the source of raw material appears to be a means of utilizing the low-grade and cull material from the hardwood timber stands.

Utilization of Spent Liquors

During the past year a second yeast plant using sugar obtained from spent sulfite liquor has come into operation. This plant will produce about 10 million pounds of Torula yeast annually for animal feed, human food, and as a basic material for pharmaceuticals (16).

Developments in the utilization of spent sulfite liquor are possibly even overshadowed by a recent announcement of a new plant to produce dimethylsulfide from kraft black liquor (spent digester liquor) (66). Dimethlysulfide appears to have potentially large markets as:

1. A base for the manufacture of solvents (dimethylsulfoxide or dimethylsulfone).
2. A sulfur carrier in agricultural chemicals or in rubber accelerators.
3. An ingredient in gas odorants.
4. A counterodorant and masking agent.
5. A chemical intermediate, since it is a small and highly reactive molecule.

Developments in Lignin Chemistry

As a continuation of the 1954 report prepared by the Chemical Utilization Subject Matter Committee, "Highlights in the Chemistry of Lignin. 1943 to 1954," (35) it seemed desirable to bring up to date the recent developments in the chemistry of lignin.

Model compound experiments have been continued as a means of studying various aspects of lignin chemistry. Prey and co-workers (71), in studying the Klason lignin balance of beechwood in soda cooking, employed coniferin and glucal as models. From the model experiments these authors concluded that a certain portion of beech wood, which gives Klason lignin, is an unsaturated carbohydrate. Pew (69) compared the alkaline nitrobenzene oxidation of sprucewood with similar oxidations of a number of model compounds and inferred from his experiments that a majority of the guaiacylpropane units in lignin are not linked by carbon substitution in the aromatic nucleus, but that there is an appreciable amount of diphenyl linkage in coniferous lignin.

Kavanagh and Pepper (42) oxidized aspen wood with alkali and nitrobenzene and determined conditions for maximum yields of vanillin and syringaldehyde, along with rates of formation of these two aldehydes. Similar experiments with glycosides and methyl ethers of these aldehydes indicated that phenolic alkyl ether link-

ages are unlikely in aspen lignin but that glycosidic-type linkages are possible.

From molecular weight and infrared studies of kraft lignins and model compounds, Lindberg (53) concluded that thiolignins in dioxane solution from three-dimensional aggregates are held together by strong hydrogen bonds. Oxidation studies of lignosulfonates have yielded vanilloylformic acid by mercuric oxide oxidation (32) and vanillil by air oxidation in the presence of lime (41). Studies have been made on Douglas-fir bark lignin (50), purified sulfate lignins (21), and lignin dissolved by methyl cellosolve from finely powdered wood (8).

Freudenberg and co-workers (25,26,27,28,29) have continued their studies on the biosynthesis of lignin from simple guaiacyl and syringyl compounds through dehydrogenation by means of enzymatic systems. Isolation of the dimer, α–[4–hydroxy–3–methoxylphenyl] –glycerol –β – [2–methoxy–4 – (γ– hydroxypropenyl)–phenyl] ether, led these authors to propose this type of building stone as being responsible for reaction with bisulfite and for the formation of an indophenol with quinone monochloroimide (30).

The mechanism of oxygen consumption during the above noted enzymatic dehydrogenations was studied by Mason and Cronyn (59) who found that there is present in crude mushroom extracts a heat-labile system which catalyzes the consumption of some oxygen by coniferyl alcohol, but it is not mushroom polyphenoloxidase. Eberhardt and Nord (19) have isolated heptolose, shikimic acid, and *p*-hydroxyphenylpyruvic acid as intermediates in the formation of methyl *p*-methoxycinnamate by growing *Lentinus lepideus* on glucose and have again indicated the role methyl *p*-methoxycinnamate might play in the lignification of plants.

The very important acid-soluble lignin was given attention by McKenzie, McPherson, and Stewart (60), who discounted the use of ultraviolet absorption spectra for its determination and described their procedure for its more accurate determination. In their method the acid-soluble lignin is absorbed on a column of ZeoCarb 215 and finally washed from this column with 95 per cent ethanol. Evaporation of the ethanol leaves the acid-soluble lignin.

Alkaline treatment of aspen wood or native aspen lignin was found by Smith (76) to yield *p*-hydroxybenzoic acid. From hydrolysis rate studies on native aspen lignin and on a number of model compounds, Smith concludes that *p*-hydroxybenzoic acid is combined with lignin through aliphatic hydroxyl groups. From similar studies on lignin from sugar cane, Smith (77) assumes the presence in native sugar cane lignin of *p*-hydroxycinnamyl groups. *p*-Hydroxybenzoic, vanillic, syringic, and ferulic acid were also found in the alkaline extract of native sugar cane lignin and native wheat straw lignin.

A number of papers have appeared on the application of physical and chemical methods to the problems of lignin chemistry. The molecular weights of lignin sulfonates (fractionated by a novel reprecipitation procedure) have been determined by light-scattering measurements (63), phenolic groups have been determined by conductometric methods (75) and by periodate oxidation (1), and functional groups have been determined by methylation studies (38).

Gierer (30) studied the blue dyestuff (indophenol) formation by reaction of quinone monochloroimide with lignin and lignin models and found that the reaction was specific for the *p*-hydroxybenzyl alcohol group. He adapted a simple colorimetric method to the determination of *p*-hydroxybenzl alcohol groups in lignin materials. Pearl and Beyer (68) have employed paper partition chromatography along with column chromatography for the isolation of pure materials from lignin oxidation mixtures.

Reaville and Shreve (72) determined acetovanillone in the presence of vanillin, *p*-hydroxybenzaldehyde, and vanillil by paper chromatography with *n*-butyl ether. Hoge (39) has adapted the Fehling solution procedure for lignin oxidation (67) for the detection of lignin on a micro scale. The specific adsorption of lignosulfonates on anionic exchange resins having only tertiary amino groups is reported by Van Blaricom and Gray (82).

Lignin Utilization

Several ideas for the utilization of lignin and lignosulfonates have been reported. Phenolic degradation products are prepared by treating spent sulfite liquor with lime at high temperature (47), dinitroguaicol is obtained by the nitration of lignin (33), and thermosetting resins are obtained from dihydric alcohols and dialdehydes prepared from lignosulfonate vanillin (9).

Spent sulfite liquor-dichromate mixtures have been found useful in preventing capillary circulation of water in road substructures (5). Spent sulfite liquor has been studied further as a tanning material. Investigations were reported on ammonia-base liquor (6), chlorinated and dechlorinated derivatives (65), and phenolic derivatives of spent liquor (44,57). A water-soluble condensation product of alkali lignin, formaldehyde, and a secondary amine was found to be useful as a tanning agent (86).

Kvasnicka and McLaughlin (51) investigated the butyl acetate extract of spruce spent sulfite liquor by means of solvent fractionation, chromatography, and countercurrent distribution and found vanilloyl methyl ketone, vanillin, dihydroconiferyl alcohol, and 4,4'-dihydroxy-3,3'-dimethoxystilbene to be present.

The complete wet combustion of lignin materials has been discussed in several articles (10,14,34,81). Purves and co-workers (52) studied the reaction of periodate lignin with sodium chlorite and with chlorine dioxide and examined the oxylignins produced. The oxylignins studied were assumed to be highly acidic chlorinated condensed quinones, which were formed by the oxidative demethylation of phenolic units in the periodate lignin.

Several reviews on lignin and lignosulfonates (23,35,43,58,62) and a detailed review on the oxidation of lignosulfonates to vanillin and its derivatives (49) have appeared.

Using Microbiological Processes

Except for the use of waste sulfite liquors, little new work has been reported on the employment of microbiological processes from a technical standpoint. Experiments were made on the use of lignin isolated by decay organisms, both naturally and artificially, to produce hardboard, molding compositions, and the like (55,64). Work on the production of chemicals by the action of rumen bacteria on wood is continuing. Considerable work of a basic nature had been described.

Several papers on the effect of decay organisms on the physical structure and properties of wood have appeared (12,74) including electron microscope studies (61). Other studies describe the chemical changes taking place (22). The presence of aromatic compounds related to vanillin has been observed in wood decayed by white rots (37). The action of bacteria and fungi on isolated lignin has continued to receive attention (24). Even such unlikely derivatives as phenol-lignin were reported to be attacked (70). Supposedly well-purified lignosulfonic acids supported mold growth, suggesting the presence of unsuspected carbohydrate (20,48).

Several papers have appeared on the digestion of cellulose by rumen bacteria (7,11,45,46) and many more on bacterial and fungal cellulytic enzymes. Attempts have been made, with some success, to separate cellulases into components with different properties and different functions in their attack on cellulosic materials (31,56,73). Other studies show something of the mecha-

nism by which cellulose chains are broken down by enzymes (36,84,85). A better understanding of the processes involved may well lead to practical means of converting cellulosic wastes microbiologically into useful chemical materials.

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Developments in Packaging in 1955[1]

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Packaging production increased about 20 per cent in dollar volume and packaging research received added emphasis during the past year. New developments are reported in paperboard containers, pallet boxes for fresh fruits and vegetables, low-temperature protection of perishable foods, preserving foods by irradiation, and outside storage of lumber. Contains bibliography of packaging references.

THE PACKAGING INDUSTRY continued its phenomenal growth in 1955, especially in the field of consumer packaging. According to the best estimate now availble, the expenditures for packaging increased to approximately $12 billion last year. Approximately $8 billion were for consumer goods and $4 billion for industrial products.

More and more products, including clothing, textile, hardware, food, and luxury items, are appearing daily in attractive and protective plastic barriers and containers. Obviously manufacturers that make sizeable investments to improve their packaging expect increased sales dividends and they are getting them. For instance, the California date growers have boosted sales 50 per cent by the use of folding paper boxes and one cigarette manufacturer, who recently adapted a new hinged, flip-lid folding paper box, increased sales 500 per cent. The National Association of Purchasing Agents reports that demand is high for all types of packaging materials.

In the industrial packaging field, the prime objective is to decrease packaging costs rather than to increase sales appeal. To effect economies, many shippers are conducting detailed studies of both their packaging and materials handling operations packaging and materials handling are being recognized as a staff responsibility. A recent survey indicates that in about 80 per cent of the companies surveyed, packaging and materials handling are handled by the same engineer. Cost control systems are being established to give the industrial supervisor an opportunity to control his packaging and materials handling costs, both for material and labor.

The increased emphasis on packaging research is evidenced by the additional laboratories constructed during the year, and by the new packaging courses offered by Columbia and New York Universities, Stevens Institute of Technology, and other educational institutions. Interest was also expressed by the growing activities of the packaging associations and societies, and by the attendance at packaging symposiums. Over 1,000 persons attended a Joint Military–Industry Symposium on packaging and materials handling held in Washington, D. C., last fall. Plans are already under way for a larger attendance at the 1956 symposium.

A brief discussion of some of the new developments follow:

Paperboard Containers

Paperboard output in 1955 totaled 14,013,251 tons, the largest for any year on record, according to the report of the National Paperboard Association. The industry operated at an average of 96 per cent of capacity which was the highest rate since 1947 when the cumulative ratio of production to capacity hit 99 per cent. However, in 1947 the industry's capacity was approximately 9–½ million tons compared with 1955's rated capacity of about 14–½ million tons. In 1954, when mills averaged only 88 per cent of capacity, the industry produced 12.2 million tons of paper-board.

The Official Rail Freight Classification Committee approved and made effective May 15, 1955, the use of a single tape closure on solid and corrugated boxes. The special reinforced tape in addition to meeting rigid material and performance requirements as stated in Section 7, Rule 41, Consolidated Freight Classification No. 20, has to be 3 inches in width and extend over the ends of the box a minimum of 2–½ inches. This rule makes it possible for the packer to tape his fiberboard boxes with automatic equipment.

A new banana box made of special weatherproof solid fiberboard has been developed. It weighs one-third as much as wood or metal boxes, and costs one-third as much as wood and one-fifth as much as metal containers.

Paperboard containers are being combined with plastics in many new developments, partially due to the reductions in price of many plastic films. A good example is the price of polyethylene which is now less in 1–¼ and 1–½-mil thicknesses than moistureproof cellophane. One of the most interesting applications of paperboard and plastics is a regular slotted, 200-pound test, corrugated exterior shipping box containing 40 pounds of cream in 4 inner bags of polyethlene for daily farm pickups of cream in place of the conventional 5-gallon metal cans. Advantages claimed are reduction in required storage space, lower tare weight for handling and freight costs, increased sanitation, and less cream spoilage.

Paperboard-plastic combinations are also finding increased use in the shipment of fresh fruits and vegetables. It has been determined that packing pears in polyethylene-lined boxes extend the storage life of the pears at least 6 weeks, decreases friction bruising of several types of pears, and practically eliminates shrivel of the pears.

Pallet Boxes for Fresh Produce

Radical changes in the handling, storage, and shipment of fresh fruits and vegetables may occur as a result of recent experiments with pallet boxes employed as a substitute for field picking boxes and shipping boxes, creates, hampers, and sacks. To date the boxes have been successfully employed in the handling and storing of potatoes, the bulk shipment of oranges and lettuce, and the handling and transportation of fresh fruits and vegetables from the field to the freeznig or canning plants.

One type of wirebound pallet box has a tare weight of approximately 100 pounds and a capacity of 25 bushels weighing up to 2,000 pounds. The dimensions of this box are 30 by 40 by 46 inches. Skids are provided so that the loaded pallets can be handled with a forklift truck.

[1] Based on information furnished by members of the FPRS Packaging Committee. Members are: A. R. Tegge, Jr., Tom Munroe, E. R. Stivers, J. R. Watkins, R. F. Weber, and G. M. Swann.

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Experience to date indicates that startling time and cost reductions are achieved with the pallet boxes. One potato grower reported that the saving on burlap bags alone was sufficient to pay for a brand new storage house, a forklift truck, and his entire supply of pallet boxes. A string bean grower states that the use of the pallet boxes reduced his handling costs 50 per cent.

Low-Temperature Protection

The Wright Air Development Center has developed a protective package for the air shipment of fresh fruits and vegetables to low-temperature areas. The fiberboard box containing the perishable food is sealed in a moisture-vaporproof barrier and this package is then wrapped with a 1-inch water-absorbent material. Another barrier is placed around the package and prior to sealing this barrier, the absorbent is saturated with water. The entire combination is then placed in the shipping container.

At –65° F., it takes approximately 6 hours for this water to freeze and until it does the temperature of the packaged product remains above freezing. A less severe exposure temperature, of course, prolongs the protection period.

Preservation of Foods

Developments during the last year in the technique of preserving foods by radiation will carry in its wake new approaches to packaging, shipping, and storing treated foods. The two most promising methods of irradiating foods are: (1) cathode rays generated by electron accelerators, and (2) gamma rays emitted by radioactive isotopes. In each of these methods foods are subjected to bombardment by ionizing radiations. The effect these radiations have depends upon the amount of energy absorbed. It is hoped that further study will result in extension of shelf life, a reduction in the degree of refrigeration needed. inhibition of sprouting in potatoes and onions, and destruction of insects and parasites.

Closely crowding irridation of foods in the packaging spotlight are the antibiotics. It has been found that poultry dipped in an aureomycin solution and then packaged and stored under commercial refrigeration could not, after 14 days, be distinguished from fresh killed birds. If continued research with antibiotics is successful, it will permit prepackaging of fresh uncooked meats at the processing level. Heretofore this has not been practical because bacteria multiply at an accelerated rate when perishables are held in packages through distribution channels.

Outside Storage of Lumber

The success of the steel-strapped unitized bundles of lumber has resulted in the development of several paper wraps for the outside storage of lumber. If these wraps perform satisfactorily the need for covered storage sheds in wholesale and retail yards will be largely eliminated.

One paper manufacturer offers an asphalt-laminated, fiber-reinforced, machine-creped kraft grade that has been used with bundles of green and dried lumber. In one series of experiments it was found that the paper wrapping practically eliminated bowing and crooking of the lumber.

It is claimed that the use of paper wraps decreases the capital investment for storage sheds, simplifies inventory taking and stock level control, protects the appearance of the lumber, and permits advertising to be placed on each bundle.

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LEIF D. ESPENAS

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Finishing Developments—1955[1]

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Discusses research and development in the wood finishing field in the past year. Improvements have been made in furniture finishes and a trend to up-grading finishes is apparent in the furniture industry. Few developments have been made in the house paint field, and the need for further research is emphasized.

INTERESTING DEVELOPMENTS have taken place in the wood finishing field in the past year. The FPRS Wood Finishing Committee has furnished the following comments concerning developments that are worth noting.

The use of hot lacquers on wood has increased and new interest has been created in airless spray painting. Artificial graining has been developed considerably and is now playing an important part in the industry.

House Paint Developments

There have been few items of new developments in the house paint field during the past year. A recent review of the literature in Industrial and Engineering Chemistry listed only four papers under house paints, two of them dealing with mildewcides, one with alkyd-resin paints of deep colors, and one on absorption of water and swelling of free films.

There is a growing opinion that new and more basic studies of the properties of house paint are needed, particularly with reference to the action of water. Besides F. L. Browne's papers published in Journal of FPRS, E. J. Dunn of National Lead Company has recently reported work in that field, there have been several in European journals, and at least one at a meeting of the British Oil and Colour Chemists at Llandudno, North Wales, in June.

Talk continues about possible future developments of latex (water-emulsion) paints for exterior use on wood. Trade literature reports test fence studies and experimental painting of houses with such paints. Such paints are now commercially available for use on masonry but are not yet seriously offered for use on wood.

Furniture Trends

Perhaps the most interesting material of the past few months is a type of pigment toner with very thin film and very high shrinkage. It gives better wood value or detail when used as undertone color for the many light finishes in demand, approaches more nearly the appearance of true bleached finishes than any similar material and system previously used.

The use of pigmented toners on mahogany, walnut, and other open-pore woods continues without any appreciable let-up. This is because of the demand for light finishes and the objections to bleaching.

There are improvements in lacquers for flow or levelling, also for clarity after rubbing and polishing. There is a further development of the synthetic wood coating much improved for rubbing and polishing.

The trend toward heat conversion varnishes continues and a great deal of work is being done to develop this type of product to dry faster, polish to a higher gloss, and have less objectionable odor in the finishing room.

The Fine Hardwoods Association is putting on a push toward burn-proof finishes, in which an aluminum sheet is used between the face veneer and the core of the panel. This is not a new idea as it has been used for several years, but is an attempt to improve the quality of such finishes—particularly the burn resistance.

In general, the trend among the furniture companies is to up-grade their finish. Some of the large production plants indicate more willingness to add the little fine touches that are necessary to give the quality appearance to the finished furniture.

New developments in wood finishing include the catalytically cured materials such as unsaturated polyesters, epoxy, and phenolics, lacquers based on low viscosity cellulose acetate butyrate, and latex paint for exterior wood.

The Tennessee Eastman Company has been promoting the cellulose acetate butyrate, and at least two papers have been prepared by its personnel. There have been no papers describing the use of latex paint on exterior wood, but some laboratories are investigating it.

[1] Committee members contributing to this report included: B. E. Clatworthy, F. L. Browne, W. E. Martin, R. I. Quigley, G. G. Sward, P. F. DeSaix, and F. H. Thomas. Other members are: R. M. Carter, D. G. Lubeck, F. X. Thompson, C. Reckers, G. Lennaeus, W. E. Pratt, D. Countryman, T. E. Werkema, D. E. Laughnan, J. C. Sarvis, A. J. Wandersleben.

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Hardboard from Extracted Juniper Chips[1]

R. G. FRASHOUR and G. D. NIXON

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Chips from western juniper that had been steam-distilled for recovery of volatile oil were ground in an attrition mill and then made into hardboard—some without additives, some with resin, and some with resin plus wax. The boards possessed exceptional bending strength and water resistance but inferior toughness properties compared with boards made from other species. Additives and higher pressing temperatures increased specific gravity values. Surfaces were uniformly colored and semiglossy without use of a water spray.

IN LARGE AREAS of central and eastern Oregon, the principal tree species is western juniper (*Juniperus occidentalis,* Hook), which is now practically unused. In an effort to find economic uses for this tree, the volatile oil content has been studied.[2]

The present report is on a study of hardboard production from juniper chips extracted by steam distillation. Harvesting the tree solely for hardboard manufacture might be uneconomic, but the practicality would be increased if the raw material could be obtained as a byproduct from another manufacturing process, such as extraction of the wood for its volatile oils.

Principal uses for the wood are restricted at present to fence posts, novelties, and fuel. Most large trees are decayed internally, thus making difficult the recovery of lumber for pencil stock.

Experimental Procedure

The work was divided into two parts, each part being analyzed separately. Part I was a short study designed to determine which of three grinding runs and chip cooks produced the best fiber for board making. The additive combinations were the same for all grinds, and two pressing temperatures (320° F. and 400° F.) were used. The plan of action followed during Part I is shown in Fig. 2.

Part II was an attempt to determine the influence of three additive treatments (no additives, resin only, and resin and wax) and temperatures on boards made with fiber from cook and grind number three. The plan of action for Part II is shown in Fig. 3.

Equipment: The chips were fiberized in a 24-inch, double-rotating-disc Bauer attrition mill. The mixing was done in a propeller-type mixer equipped with two spray heads for additive distribution. The mat felter was laboratory-designed, as was the pre-pressing equipment. All boards were pressed with mats at 40 per cent volatile content in a steam-heated hydraulic press.

Preparation of Fiber: Chips were supplied as a by-product from volatile oil extraction. All chips used had been screened to 5/8-inch size and cooked under one of the following conditions:

1. Steam pressure, 25 psi for 6 hours.
2. Steam pressure, 25 psi for 5 hours.
3. Steam pressure, 45 psi for 8 hours.

The chips were fiberized hot. Cook number one was ground using a plate setting of 23 mils, which was the same setting used on previous studies of lodgepole pine and Douglas-fir.[3] Be-

[3] Nixon, G. D. 1953. Suitability of Lodgepole Pine for Dry-formed Hardboard. Report No. L-3, Oregon Forest Products Laboratory.

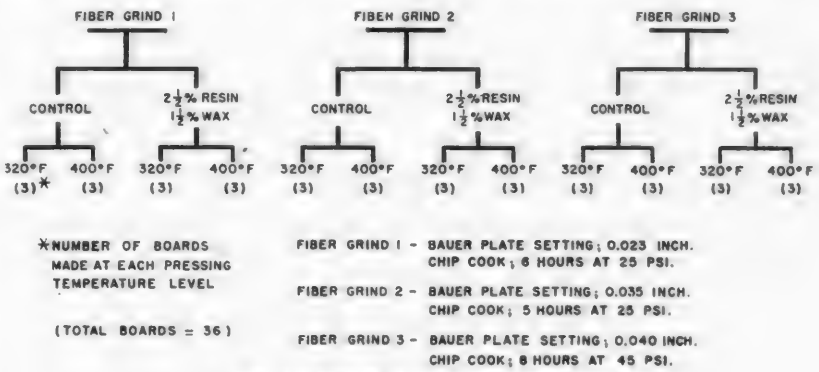
FIBER GRIND 1
FIBER GRIND 2
FIBER GRIND 3
CONTROL
2½% RESIN
1½% WAX
320°F
400°F
(3)*
(3)
*NUMBER OF BOARDS MADE AT EACH PRESSING TEMPERATURE LEVEL
(TOTAL BOARDS = 36)
FIBER GRIND 1 - BAUER PLATE SETTING; 0.023 INCH. CHIP COOK; 6 HOURS AT 25 PSI.
FIBER GRIND 2 - BAUER PLATE SETTING; 0.035 INCH. CHIP COOK; 5 HOURS AT 25 PSI.
FIBER GRIND 3 - BAUER PLATE SETTING; 0.040 INCH. CHIP COOK; 8 HOURS AT 45 PSI.

Fig. 2.—Plan of action used in Part I.

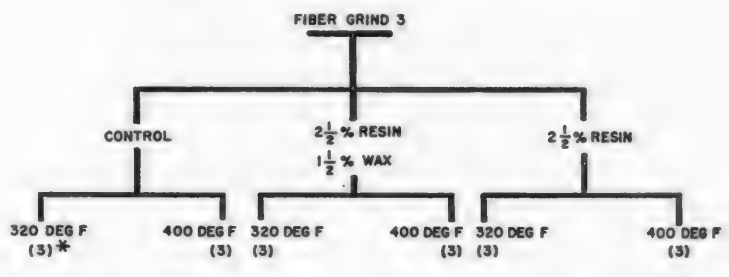

Fig. 3.—Plan of action used in Part II.

[1] A contributed paper.

[2] Kurth, E. F., and Ross, J. D. Volatile Oil from Western Juniper. Report No. C-3, Oregon Forest Products Laboratory. April, 1954.

The Authors: Ronald G. Frashour is research associate in the Manufactured Products section at the Oregon lab. He received B.S. from Oregon State College in 1951.

Gaylord D. Nixon received B.S. from Oregon State College in 1951, worked two years as wood technologist in Manufactured Products section of the Oregon lab before joining Plastics Division of Monsanto Chemical Co. in Sept. 1[illegible].

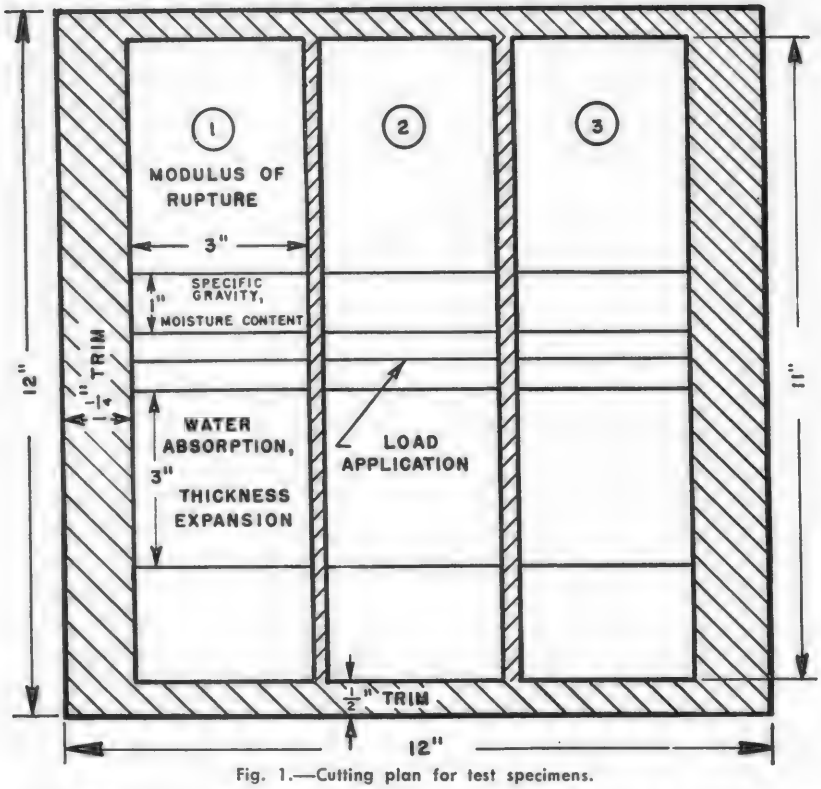

Fig. 1.—Cutting plan for test specimens.

cause of the extended cooking times the chips were soft and pliable, yielding short fiber with a high percentage of fines.

The second cook was ground at a faster feed rate and with a plate setting of 35 mils. The objective in increasing the plate setting was to produce a coarser fiber. This grind gave fiber which appeared to approximate the fiber-size distribution obtained from lodgepole pine and Douglas-fir.

The third cook, which was steamed at 45 psi, was ground at a plate setting of 40 mils to give a fiber with distribution comparable to that of cook number two. In order to maintain a full load on the Bauer mill, it was necessary to further increase the feed rate. The extracted juniper chips required less power for grinding than did lodgepole pine or Douglas-fir.

All grinds were analyzed for fiber distribution in a Bauer–McNett fiber classifier, and the results of the analysis are shown in Table 2.

Preparation of Boards: The wet fiber from all grinds was dried to below 15 per cent moisture content (on a dry-weight basis) before further processing. The dried fiber was mixed with the necessary amounts of resin, wax, and water. The mixed fiber was felted into a loose mat by means of a shaker box and pre-pressed by an air-operated ram. Following the prepressing, the mats were pressed into screen-backed boards in a steam-heated hydraulic press using a pressing cycle of 1000 psi for 45 seconds, then released to 100 psi for 9 minutes, 15 seconds. This was the same pressing cycle used on previous studies of lodgepole pine, Douglas-fir, and West Coast hemlock. The volatile content of the fiber at time of pressing was about 40 per cent (oven-dry weight basis).

Forty-two boards were made, 12 by 12 by ¼ inches, and smooth one side. No pH control was used with these boards because of the low pH of the raw material. A phenolic resin binder was used throughout the study and a wax emulsion was used to reduce water absorption. The combination of resin and wax was used because it had given satisfactory results in hardboard using lodgepole pine, West Coast hemlock, and Douglas-fir fibers. The amounts of additives were kept constant throughout the work at either 2½ per cent resin, or 2½ per cent resin plus 1½ per cent wax emulsion.

Testing of Boards: Test values for modulus of rupture, water absorption, specific gravity, and moisture content at time of testing were obtained for all boards. Test specimens were cut from the 12- by 12-inch boards in accordance with the pattern shown in Fig. 1. All boards to be tested were conditioned for one week at 65 per cent relative humidity and 70° F.

Modulus of rupture values were obtained from 3-inch by 11-inch test specimens, broken on an 8-inch span with a head speed of 4 inches per minute (Federal Specification LLL–F–311).

Water absorption test specimens were cut as 3- by 3-inch pieces, taken from the broken bending specimens. After initial weight and thickness measurements were taken, the pieces were immersed for 24 hours under 1 inch of water at 70° F. Upon removal from the water the pieces were set on edge and allowed to drain for 10 minutes. Final weights and thicknesses were recorded and values for water absorption and thickness swelling calculated as percentages of the original weight and thickness. The standard size for a 24-hour water absorption test specimen is 12 by 12 inches; therefore the values obtained from these smaller pieces should be somewhat higher than would be expected from full-size test pieces.

Specific gravity values were determined from 1- by 3-inch sections that were taken also from the bending specimens. The pieces first were weighed, then oven-dried and weighed a second time. Volume measurements were made by immersion of the piece in mercury, and the weights and volumes were used to calculate moisture content at test, and specific gravity. Specific gravity values were based on oven-dry weight and oven-dry volume.

Results and Discussion

Part I

Data pertinent to the steaming, grinding, and fiber-size distribution from the four digester loads are shown in Tables 1 and 2. The fourth digester load was run as a continuation of load 3 and the resultant fibers were considered the same.

The data in Table 2 show that the juniper chips produced a shorter fiber with more fines than in fiber from any of the previous anlayzed species. Where a comparable plate setting was used (grind 1) an extremely fine fiber resulted, but when coarser plate settings were used the fiber-size distribution more closely approached that of previous species studied.

All the juniper boards were characterized by a glossy, uniformly colored surface on the smooth side, regardless of the pressing temperature used. Boards made from the extremely fine fiber of grind 1 produced superior surface characteristics, although the boards from grinds 2 and 3 were comparable to commercial products. It was unnecessary to water-spray the mat for uniform surface color of boards.

Because of the extended cooking times (5–8 hours), somewhat more water solubles than previously experienced with other species were deposited on the screen back. The deposit did not cause serious sticking of the fiber to the screen, but in a commercial operation it would seem desirable to

brush off this somewhat sticky material.

Test results of boards made during this part of the project are shown in Table 3.

Each value given in the table represents an average of nine test values. The modulus of rupture, Izod toughness, specific gravity, and water-absorption test data were analyzed statistically by an analysis of variance with the grinding run, additive treatment, and press temperature set up as the major sources of variation. The results of the analysis of each property follow.

Modulus of Rupture: The bending strength of the boards containing additives was well above Federal Specification LLL–F–311 (5500 psi). The juniper boards were somewhat stronger than lodgepole pine boards and weaker than West Coast hemlock boards pressed under the same conditions.

The inclusion of resin and wax significantly increased the bending strength of the boards regardless of the fiber grind or press temperature used. Boards made with fiber from grind 3 were slightly lower in strength where resin and wax were used, but exhibited the same strength as the other grinds where no additives were used. In addition, resin and wax effected a greater strength increase where the boards were pressed at the lower press temperature (320° F.) The boards pressed at 400° F. possessed significantly greater bending strength than did those pressed at 320° F. Although small differences occurred between the average strength values of the boards made with the different fiber grinds, there appeared to be no important effect caused by chip steaming conditions or Bauer plate settings.

Izod Toughness: The most interesting result of the toughness test values was the superior toughness exhibited by the boards made with fiber from grind 2, irrespective of press temperature or additive treatment. This property was apparently influenced by both fiber-size distribution (grind 1) and chip steaming conditions (grind 3).

As expected, the boards pressed at the higher temperature were considerably lower in toughness. Boards containing no additives showed a greater drop in toughness than did those with resin and wax added. The inclusion of resin and wax lowered toughness values in boards pressed at both temperatures. The lowering of toughness because of the influence of additives was more pronounced in boards pressed at the lower temperature (320° F.)

Water Absorption: The juniper boards were superior in water resistance to either lodgepole pine or West Coast hemlock boards pressed under similar conditions. As expected, the addition of resin and wax produced boards with superior water resistance. The magnitude of this effect was influenced by the press temperatures. At 400° F. press temperature, the actual reduction in water absorption brought about by the addition of additives was less than for boards pressed at 320° F.; however, the percentage reduction was about the same.

Boards pressed at the higher press temperature showed superior water resistance. All boards with resin and wax pressed at this temperature were well within the proposed commercial specifications (16 per cent) while those pressed at 320° F. were close to meeting the standard when the small (3- by 3-inch) specimen size was considered. The type of fiber used had no significant effect on water absorption.

Specific Gravity: The addition of resin and wax significantly increased the specific gravity of the boards, regardless of the pressing temperature used. Increasing press temperature from 320 to 400° F. increased the specific gravity in boards containing no additives, but did not effect a significant change in those boards containing additives. Fiber ground at the closest plate setting (23 mils) produced boards with significantly greater specific gravity than that of those ground at the coarser plate settings (35 and 40 mils).

Tables showing average values for the previously mentioned combinations are presented in the appendix, with their respective LSD (least significant difference) values. The LSD values are used as a yardstick to measure the magnitude of change necessary to constitute a significant difference.

Table 1.—JUNIPER CHIP STEAMING AND GRINDING DATA

Run	Initial chip moisture content Per cent	Steam temperature Deg F.	Steam time Hours	Steamed chip moisture content Per cent	Bauer plate settings Mils	Fiber moisture content Per cent
1	30–40	267	6	162	23	111
2	30–40	267	5	---	35	85
3	30–40	300	8	---	40	130
4	14	300	8	---	40	95

Table 2.—SCREEN ANALYSIS OF JUNIPER FIBER COMPARED WITH OTHER SPECIES

Species	Plate setting Mils	Mesh size; openings per inch: Retained 20	Passed 20 Retained 35	Passed 35 Retained 65	Passed 65 Retained 150	Passed 150 (by difference)
				Per cent		
Western juniper (Grind)						
1	23	(0)*	50.6 (61.6)	19.9 (24.2)	11.6 (14.1)	17.9
2	35	36.6 (43.6)	27.6 (32.9)	12.7 (15.1)	7.0 (8.3)	16.1
3	40	37.7 (46.7)	21.3 (26.4)	14.0 (17.3)	7.8 (9.6)	19.2
4	40	39.6 (49.0)	19.0 (23.5)	13.9 (17.2)	8.3 (10.3)	19.2
Lodgepole pine	25	58.7 (67.8)	17.7 (20.4)	7.1 (8.2)	3.1 (3.6)	13.4
Douglas fir	25	50.2 (56.2)	22.0 (24.6)	11.1 (12.4)	6.1 (6.8)	10.6
West Coast hemlock	25	57.2 (62.9)	20.5 (22.5)	9.3 (10.2)	4.0 (4.4)	9.0

*Values inside parentheses indicate percentage if last fraction containing water solubles is ignored.

Table 3.—TEST RESULTS OF BOARDS MADE FROM THREE FIBER GRINDS, WITH AND WITHOUT ADDITIVES AND PRESSED AT 320 AND 400° F. (COMBINED VALUES FOR PARTS I AND II)

Press temperature Degree F	Property	Grind: No. 1 No additives	No. 1 Resin and wax	No. 2 No additives	No. 2 Resin and wax	No. 3* No additives	No. 3* Resin and wax	No. 3* Resin only
320	Modulus of rupture (psi)	3740	6840	3730	7020	3880	6170	6950
	Toughness (in.-lb.)	10.25	6.56	12.25	7.30	10.50	6.61	8.56
	Specific gravity	0.98	1.04	0.96	1.04	0.98	1.00	1.00
	Water absorption (%)	52.4	17.7	61.5	18.9	51.6	17.7	35.2
	Thickness swell (%)	21.9	7.0	29.5	5.9	21.7	4.7	11.0
	pH of fiber	4.0	5.4	3.9	5.1	4.1	5.5	5.5
400	Modulus of rupture (psi)	5060	7310	5400	7270	5380	7270	7490
	Toughness (in.-lb.)	7.00	5.60	8.00	6.24	7.25	5.54	6.33
	Specific gravity	1.00	1.03	0.98	1.00	0.99	1.02	1.04
	Water absorption (%)	40.4	13.7	44.3	13.7	38.1	13.6	32.6
	Thickness swell (%)	13.8	4.3	16.6	4.1	12.8	3.5	9.3
	pH of fiber	4.0	5.4	3.9	5.1	4.1	5.3	5.8

*Values for grind 3 include results from Parts I and II.

Results and Discussion

Part II

The results from this part of the study also were analyzed statistically for modulus of rupture, Izod toughness, water absorption, and specific gravity.

For this analysis, only additive condition (resin and wax or resin only or no additives) and press temperature (320 or 400° F.) were set up as the main variables since the same type (grind 3) of fiber was used throughout. Average values for this part of the project are included in Table 3 in the column headed Grind No. 3.

Modulus of Rupture: An increase in press temperature from 320 to 400° F. resulted in a significant increase in strength of all fiber treatments. Higher strength values because of the rise in temperature were most noticeable in control boards, which showed 39 per cent higher values for modulus of rupture at the 400° F. pressing temperature.

In boards containing both resin and wax, the increase in modulus of rupture was 17.8 per cent, while those with resin alone were increased by 7.8 per cent. The addition of either resin alone or resin in combination with wax caused a significant increase in bending strength. Boards pressed at 320° F. containing both resin and wax had significantly lower strength than that of boards containing resin alone. Boards containing wax and resin, when pressed at 400° F., had only a slightly lower average modulus of rupture value than did the boards containing resin alone. This result indicates that the serious strength-reducing effect of wax noted at the 320° F. pressing temperature did not exist at the higher temperature.

Izod Toughness: Both additives and temperature had a significant effect on toughness values. Boards containing no additives possessed greater toughness than did those with resin only, and those with resin only showed greater toughness than did the boards with resin and wax. However, the difference between boards with resin only as compared with boards containing resin and wax at the higher temperature level was not significant.

An increase in pressing temperature lowered the toughness values in every fiber treatment condition. Higher temperature caused the greatest decrease in toughness values in the control boards (no additives).

Water Absorption: Additive treatment caused a significant difference in water absorption in all fiber conditions. The addition of resin alone decreased water absorption when compared to the control boards, and the addition of resin with wax caused a significant decrease when compared to boards with resin alone.

An increase in pressing temperature increased water resistance in the control boards and in boards containing resin and wax. There was no significant decrease in water absorption caused by an increase in temperature when resin alone was added.

Specific Gravity: Boards containing additives showed significantly higher specific gravity than did control boards. Boards pressed at the higher temperature also had higher specific gravity.

Remarks

Juniper boards (both with and without additives, and at both pressing temperatures), when compared with boards made from lodgepole pine and Douglas-fir, were found to possess exceptional bending strength and water resistance but their toughness properties were generally inferior.

The inferior toughness probably can be traced to the extended chip steaming times (5–8 hours). The impact strength and toughness of most wood is impaired by exposure to high temperatures for extended periods of time.

The juniper boards were noticeably more uniform in specific gravity than were boards from other species pressed under the same conditions. Superior fiber flow characteristic was evidenced by the uniformly colored, semiglossy surface of all boards, without the use of water spray on the surface.

Appendix
Statistical Analysis

Table 4.—AVERAGE VALUES WITH LEAST SIGNIFICANT DIFFERENCES FOR PART I

Variable	Additives: None	Additives: Resin and wax	LSD*
MODULUS OF RUPTURE			
Grinds			
1	4400	7080	)2
2	4570	7150	)
3	4630	6720	)
Temperature			
320° F.	3780	6680	)
400° F.	5280	7280	)23
WATER ABSORPTION			
Temperature			
320° F.	55.2	18.1	)
400° F.	40.9	13.7	)5.
TOUGHNESS			
Grinds			
1	7.36	-----	)
2	8.39	-----	)0.4
3	7.44	-----	)
Temperature			
320° F.	10.96	7.37	)
400° F.	6.82	5.79	)0.4
SPECIFIC GRAVITY			
Grinds			
1	1.013	-----	)
2	0.995	-----	)0.0 3
3	0.998	-----	)
Temperature			
320° F.	0.973	0.990	)
400° F.	1.027	1.017	)0.0

*Least significant difference.

Table 6.—AVERAGE VALUES WITH LEAST SIGNIFICANT DIFFERENCES FOR PART II

Variables: Other	Additives: None	Resin	Resin and wax	LSD*
MODULUS OF RUPTURE	4630	7220	6720	150
Temperature				
320° F.	3880	6950	6170	)
400° F.	5380	7490	7270	)450
WATER ABSORPTION	44.9	33.9	15.6	3.7
Temperature				
320° F.	51.7	35.2	17.7	)
400° F.	38.1	32.6	13.6	)3.8
TOUGHNESS	9.15	7.44	6.31	0.6
Temperature				
320° F.	10.42	8.56	6.61	)
400° F.	7.19	6.33	5.54	)0.8
SPECIFIC GRAVITY	0.989	1.019	1.012	0.019
Temperature only				
320° F.	0.99			
400° F.	1.02			

*Least significant difference.

Table 5.—SUMMARY OF STATISTICAL ANALYSIS FOR PART I

Source of Variation	Modulus of rupture	Water absorption	Toughness	Specific gravity
Grinds	NS*	NS	S	S
Additives	S†	S	S	S
Temperatures	S	S	S	NS
Grinds and additives	S	NS	NS	NS
Grinds and temperatures	NS	NS	NS	NS
Additives and temperatures	S	S	S	S
Grinds and additives and temperature	NS	NS	NS	NS

*Not significant.
†Significant.

Table 7.—SUMMARY OF STATISTICAL ANALYSIS FOR PART II

Source of Variation	Modulus of rupture	Water absorption	Toughness	Specif gravit
Additives	S*	S	S	S
Temperature	S	S	S	S
Additives and temperature	S	S	S	NS†

*Significant.
†Not significant.

Exploratory Tests to Increase Preservative Penetration in Spruce and Aspen by Mold Infection[1]

GEORG SCHULZ[2]

Collaborator, Forest Products Laboratory,[3] Forest Service, U. S. Department of Agriculture

Exploratory tests were made of effect of heavy mold infection on absorption and penetration of an oil preservative in black spruce and aspen of fence-post size. In tests employing both soaking and pressure treatments, absorption and penetration of the oil preservative solution usually were 3 to 5 times greater in heavily mold-infected than in mold-free or slightly mold-infected wood. The author contemplates further tests to explore methods of overcoming difficulties in adequately treating spruce and poplar species with oil preservatives.

Introduction

DIFFERENCES IN THE ANATOMY AND STRUCTURE of various species of wood affect their treatability by preservative materials. Some species, for instance, resist the penetration of oil preservatives to such an extent that they are not treated widely with such solutions. This inability to impregnate certain woods with oil preservatives is important in countries such as Germany that do not have a wide selection of species for treating purposes.

Since the loss of its eastern pine forests, Western Germany has found it necessary to use woods like spruce for telephone poles. Although spruce is now being treated with water-carried preservatives, the average service life of such poles is less than it would be if coal-tar creosote or some similar oil preservative could be used. Liese (2) and others have studied the structure of spruce, but successful procedures for treating this wood in practice with oil preservatives are still unknown.

Common woods that often are not uniformly penetrated by oil preservatives are represented by various species of the genus *Populus*. In the United States, aspen presents a problem along this line for round products of fence-post or larger size (1). Since the planting of poplars has increased steadily in Europe, greater amounts of this type of wood probably will be used for purposes requiring preservative treatment.

The present tests were conducted to determine the effect of mold infection of spruce and aspen on the absorption and penetration of an oil preservative. Interest in the subject was stimulated by the studies of Lindgren (3), who found that heavy mold infection greatly increased the penetrability of southern pine to oil- and water-carried solutions. Heavy mold infection in these earlier tests was encouraged by dipping the wood in certain chemical solutions immediately after peeling and before seasoning.

Since the present comparisons were exploratory, only a brief discussion of the results will be presented. The author intends to amplify these tests in Germany, with particular reference to the possible use of mold infection as a practical means of improving the treatability of spruce and poplar species.

Methods of Study

Preparation of Wood for Treatment: Freshly cut black spruce and aspen trees were sawed into pieces of 1-1/3 to 2 feet (40 to 60 centimeters) in length, and 2½ to 5 inches (6 to 12 centimeters) in diameter. Immediately after sawing, the bark was completely removed and the pieces dipped for 20 seconds in one of the chemical solutions shown in Table 1. It was hoped that those chemicals containing fluoride and arsenic would encourage heavy mold development. Solutions containing sodium pentachlorophenate were used to prevent mold infection and thereby to serve as controls in assaying the importance of infection.

After it was dipped, the test material was dried slowly by first placing it in a room maintained at 80° F. (27° C.) and 97 per cent relative humidity, and then in other conditioning rooms, according to the following schedule:

Spruce		Aspen	
Relative humidity, Per cent	Days	Relative humidity, Per cent	Days
97	16	97	11
80	8	80	14
65	14	65	30
		30	15

At the end of the drying period, moisture content of the spruce pieces ranged from 12 to 25 per cent, depending on diameter of the piece. In the case of aspen, moisture content after drying varied and tended to remain fairly high in the larger pieces. For instance, the outer ½ inch usually approached 15 per cent and the middle zones about 25 per cent, but the centers ran as high as 60 per cent moisture content. Some of this slow drying of the larger pieces was associated with a "wet wood" condition of the interior. The smaller aspen pieces showed moisture content values that were similar to those in spruce.

The development of mold infection on the pieces during the first 8 days

Table 1.—SURFACE DEVELOPMENT OF MOLD ON UNSEASONED SPRUCE AND ASPEN POST WOOD 8 DAYS AFTER IT WAS DIPPED IN DIFFERENT CHEMICAL SOLUTIONS

Spruce			Aspen		
Dipping solution			Dipping solution		
Kind	Concentration Per cent	Mold amount*	Kind	Concentration Per cent	Mold amount*
Ammonium silicofluoride	4	1–2	Ammonium silicofluoride	1	5
Ammonium silicofluoride	2	2	Ammonium silicofluoride	.5	3
Ammonium silicofluoride	1	3–4	Sodium fluoride	2	4
Ammonium silicofluoride	.5	4	Sodium fluoride	1	3
Sodium fluoride	4	2–3	Arsenic acid	1	3–4
Sodium fluoride	2	3	Arsenic acid	.5	3
Sodium fluoride	1	3	Sodium pentachlorophenate plus borax (40–60 per cent)	2.5	1
Sodium fluoride	.5	3–4	Water	---	1
Sodium pentachlorophenate	5	0			
Water	---	1			

*Surface molding rated as 0 (none) to 5 (complete coverage).

[1] A contributed paper.

[2] In the U.S.A. on Fulbright and Department of State grant. Home institution: Biologische Bundesantalt Für Land-und Forstwistschaft. Institut für forstliche Mykologie und Holzschutz, Hann Münden, Germany.

[3] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[4] Numbers in parentheses refer to literature cited.

The Author: Georg Schulz spent nine months in 1954–55 at the U. S. Forest Products Laboratory as a Fulbright Fellow, working on problems of wood pathology and preservation. He holds Diploma in Forestry and Doctor of Forest Science from U. of Gotingen, is now associated with Institute for Forest Mycology and Wood Protection, Hannover, Munden, Germany.

Table 2.—ABSORPTION OF AN OIL PRESERVATIVE SOLUTION BY END-COATED SPRUCE AND ASPEN POST SECTIONS WITH DIFFERENT AMOUNTS OF MOLD INFECTION, AFTER COLD-SOAKING FOR PERIODS UP TO 42 HOURS

Average piece diameter In. (cm.)	Preliminary dipping solution		Surface mold amount*	Absorption after†		
	Kind	Concentration Per cent		½ hour	24 hours	42 hours
		SPRUCE				
2.6 (6.5)	Ammonium silicofluoride	4	3	4.5 (72)	11.5 (184)	12.0 (191)
2.5 (6.3)	Ammonium silicofluoride	2	3	1.5 (24)	3.0 (47)	3.1 (50)
2.6 (6.5)	Ammonium silicofluoride	1	4	0.7 (11)	1.8 (29)	1.9 (31)
2.4 (6.0)	Sodium fluoride	4	3	0.4 (7)	1.2 (20)	1.3 (22)
2.5 (6.2)	Sodium fluoride	2	3	0.2 (3)	0.8 (13)	0.9 (15)
2.9 (7.2)	Sodium fluoride	1	3	1.2 (19)	3.0 (48)	3.3 (52)
2.4 (6.0)	Sodium pentachlorophenate	5	0	0.1 (1)	0.2 (2.4)	0.2 (3)
2.2 (5.4)	Water	---	1	0.4 (6)	0.9 (15)	1.1 (17)
		ASPEN				
3.5 (8.7)	Ammonium silicofluoride	1	5	1.2 (19)	3.3 (53)	3.7 (59)
2.9 (7.2)	Sodium fluoride	2	4	1.3 (20)	3.7 (59)	4.5 (72)
3.0 (7.5)	Sodium fluoride	1	3	1.4 (22)	2.9 (47)	3.2 (51)
2.6 (6.5)	Arsenic acid	1	5	4.2 (67)	11.5 (184)	12.3 (197
3.2 (8.0)	Arsenic acid	.5	4	1.8 (29)	4.2 (68)	5.1 (81)
2.9 (7.2)	Sodium penta + borax	2.5	2	1.4 (22)	2.7 (42)	2.7 (43)
2.9 (7.2)	Water	---	1	0.2 (3)	0.6 (10)	0.7 (12)

*0 (none) to 5 (heavy).
†The first value in each column is in pounds per cubic foot, the second in kilograms per cubic meter. Each value is based on 1 section for spruce and an average of 2 or 3 sections for aspen.

of exposure is shown in Table 1. Mold infection was observed on certain groups within 2 or 3 days after dipping and first appeared as white fluffy mycelium. Within a week, colored mold spores were evident on the surfaces of many of the pieces. Heavy development of the common green *Trichoderma* mold was particularly conspicuous on all pieces dipped in solutions of sodium fluoride or ammonium silicofluoride. Pieces dipped in the arsenic solution showed a variety of molds, including *Trichoderma* and yellowish-white, orange-pink, and black-brown colored species. In contrast, a 5 per cent solution of sodium pentachlorophenate inhibited fungus growth on spruce. A 2.5 per cent solution of sodium pentachlorophenate plus borax permitted scattered light molding on aspen.

Later observations preceding preservative treatment showed more uniform and thorough development of mold on the wood dipped in fluoride or arsenic solutions than is indicated in Table 1 for the 8-day observation period. In general, the reports of Lindgren (3) and Verrall (4) that certain chemicals encourage specific mold fungi were confirmed. No attempt was made in these studies to correlate interior mold infection with that appearing on the surfaces. It is recognized that surface appearance is not always an exact criterion of the amount of fungus development in the wood.

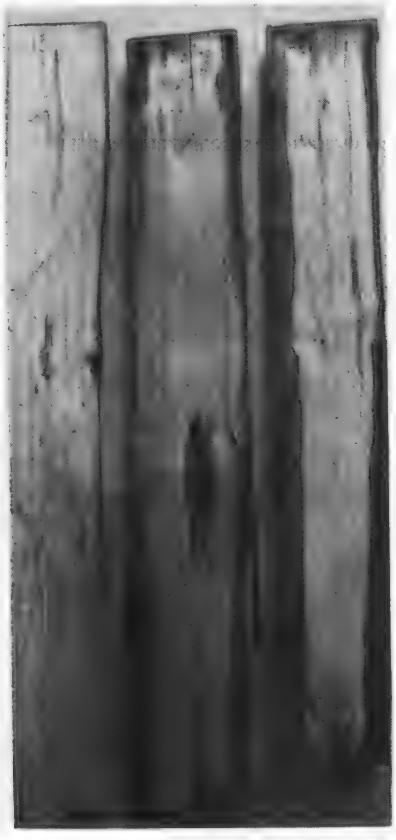

Fig. 1.—Side penetration of black spruce by cold soaking in an oil preservative solution. Description given under Results and Discussion.

Treatment of Wood: After drying according to the above schedule, the pieces were prepared for treatment with an oil preservative solution. Surface mold was scraped from the wood and each piece was end coated with two applications of a resorcinol resin to prevent end penetration of the preservative solution. Volumes and weights of the pieces were then determined.

Two different schedules were employed in treating the test material with a 50–50 mixture of coal-tar creosote and fuel oil. One schedule involved cold-soaking the material in the preservative solution for different lengths of time over a 42-hour period, with absorptions determined after ½, 2–½, 8–½, 24 and 42 hours of soaking. For the second schedule, preservative at a temperature of 82° F. (28° C.) was injected into the wood by the Lowry empty-cell process under a pressure of 75 pounds per square inch over a 4-hour period.

Table 3.—ABSORPTION OF OIL PRESERVATIVE BY END-COATED SPRUCE AND ASPEN POST SECTIONS WITH DIFFERENT AMOUNTS OF MOLD INFECTION, AFTER A 4-HOUR PRESSURE TREATMENT AT 75 POUNDS PER SQUARE INCH

Average diameter of samples In. (cm.)	Preliminary dipping solution		Surface mold amount*	Preservative absorption†	
	Kind	Concentration Per cent		Lbs. per cu. ft.	Kg. per m
		SPRUCE			
3.4 (8.6)	Ammonium silicofluoride	4	3	15.1	241
3.6 (9.1)	Ammonium silicofluoride	2	3	15.5	248
3.3 (8.3)	Ammonium silicofluoride	1	4	15.2	244
2.7 (6.8)	Ammonium silicofluoride	.5	5	18.5	297
3.4 (8.6)	Sodium fluoride	4	3	15.4	247
3.7 (9.2)	Sodium fluoride	2	3	9.3	149
3.1 (7.8)	Sodium fluoride	1	3	14.9	239
2.7 (6.8)	Sodium fluoride	.5	4	15.7	251
3.9 (9.7)	Sodium pentachlorophenate	5	0	3.6	58
3.4 (8.5)	Water	---	2	13.6	218
		ASPEN			
4.4 (10.9)	Ammonium silicofluoride	1	5	20.8	334
4.6 (11.6)	Ammonium silicofluoride	.5	3	18.0	288
4.5 (11.2)	Sodium fluoride	2	4	16.7	267
3.6 (9.0)	Sodium fluoride	1	3	19.3	309
4.1 (10.2)	Arsenic acid	1	5	24.8	396
4.6 (11.5)	Arsenic acid	.5	4	20.9	334
4.2 (10.5)	Sodium pentachlorophenate plus borax	2.5	2	10.1	162
4.3 (10.7)	Water	---	1	8.7	140

*0 (none) to 5 (heavy).
†Each value is based on 1 section for spruce and an average of 2 or 3 sections for aspen.

Results and Discussion

Fig. 1 shows the extent of side penetration of black spruce by cold soaking in an oil preservative solution. From left to right, the pieces were given a preliminary dip in sodium pentachlorophenate, 2.0 per cent ammonium silicofluoride and 4.0 per cent ammonium silicofluoride. The left piece remained mold-free, while the two dipped in the silicofluoride were moderately mold-infected on the surface. Absorptions were 0.2, 3.1, and 12.0 pounds per cubic foot, respectively.

Absorptions of oil preservative solution by the spruce and aspen after cold-soaking for several periods are summarized in Table 2. In spruce, absorptions were not closely correlated with the amount of surface mold development. However, the two groups with little or no mold infection had absorbed only 1 pound or less of solution per cubic foot after 42 hours. In contrast, average absorptions in 5 of the 6 mold-infected groups were more than 1 pound, and in 1 case reached 12 pounds per cubic foot. The results for aspen showed a fairly close correlation between amount of surface mold and pickup of preservative solution. Again, absorption after 42 hours was less than 1 pound for the group with least mold, whereas the other mold-infected groups retained 3 to 12 pounds.

Penetration of solution in the soaked spruce and aspen was directly related to the amount of preservative absorbed by the wood. With absorptions of about 12 pounds per cubic foot, penetration averaged ½ inch (13 millimeters) in spruce (Fig. 1), and was almost as deep in the aspen. This depth represented the approximate thickness of sapwood, particularly in the spruce. With the lower absorptions of 1 pound or less, penetration of the solution was confined to the surface layers of the wood.

Table 3 and Figs. 2 and 3 present the results obtained by applying the preservative solution by pressure. Fig. 2 shows the extent of penetration of black spruce by an oil preservative solution applied under pressure. Oil beyond the dotted black lines represents creeping of preservative after the pieces were cut. The left piece was mold-free at the time of treatment, while the others were moderately to heavily mold-infected. Penetration of the mold-free piece averaged ⅛ inch, and 3.6 pounds of preservative were absorbed per cubic foot. Penetration of the heavily mold-infected pieces averaged ½ inch, with an average absorption of about 16 pounds per cubic foot.

Fig. 3 shows the result of this pressure treatment on aspen. Piece No. 20 was lightly mold-infected after a dip in water, as was No. 2 after a dip in sodium pentachlorophenate plus borax. No. 25 was moderately to heavily mold-infected, and Nos. 12 and 13 were heavily mold-infected after a dip in arsenic acid. Penetrations and absorptions ranged from ⅛ inch and 7.8 pounds of preservative per cubic foot for the piece dipped in water to nearly complete penetration and about 25 pounds per cubic foot for the 2 heavily mold-infected pieces dipped in arsenic acid.

Absorptions obtained by pressure treatment tended to be more uniform than in the soaking treatment, and the

Fig. 2.—Side penetration of black spruce by an oil preservative solution applied under pressure. Description given under Results and Discussion.

Fig. 3.—Side penetration of aspen by an oil preservative solution applied under pressure. Description given under Results and Discussion.

groups with least surface mold infection retained the smallest amount of solution. In general, 3 to 5 times more solution was absorbed by mold-infected than by bright spruce, and 2 to 3 times more by the mold-infected aspen. Penetration of the sapwood in mold-infected spruce often was complete (about ½ inch or 13 to 14 millimeters), whereas that in the bright wood usually did not exceed ⅛ inch (3 millimeters). Similar differences occurred in aspen and in a few cases were even more pronounced (Fig. 3).

These exploratory tests indicated clearly that heavy mold infection can be induced on spruce and aspen and that such infection increases the permeability of the wood. However, the data were too meager to determine whether the fluorine- or arsenic-containing solution was more effective in encouraging mold infection. On aspen at least, the arsenic acid solution led to the development of a wider variety of molds and the greatest absorption of oil preservative.

As expected from earlier reports (3), the fluorine-containing solutions especially favored heavy growth of the common green *Trichoderma* mold. The increased permeability of wood with profuse *Trichoderma* infection was reportedly associated with a partial or complete breakdown of the ray and other parenchyma cells.

Further study will be required to determine whether this explanation holds true for the infected spruce and aspen in these tests. Likewise, more work is necessary to determine the prospects of employing mold infection as a practical means of improving the treatability of these woods.

Acknowledgments

The author expresses his appreciation to the U. S. Forest Products Laboratory where he had the pleasure of pursuing his investigations for about nine months in 1954–55. Particular thanks are given to members of the Division of Forest Disease Research for their friendly cooperation and guidance.

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Fungicidal Toxicity of Certain Extraneous Components of Douglas-Fir Heartwood[1,2]

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Douglas-fir heartwood offers some resistance to attack by fungi due to the presence of certain chemicals. Although present only in small amounts, these compounds exert a toxic effect on wood-destroying fungi. Lumber containing high amounts of taxifolin, the most potent fungicidal material in Douglas-fir, can be expected to last longer than unselected material when exposed to conditions favoring decay.

IT IS IMPORTANT that the factors influencing the natural decay resistance of major timber species be fully understood, so that those woods exhibiting high resistance may be more effectively utilized. If the factors responsible for durability within a species were known, that timber exhibiting a preponderance of these factors would be more acceptable under conditions favoring decay. Products made from such timber could be expected to last longer in service than those manufactured from unselected material.

The possibility of breeding highly durable genetic types within resistant species also exists. This might be accomplished by using as a seed source only those trees displaying the highest degree of durability factors.

Timber is often rendered more durable by applying preservatives under pressure. Although the heartwood of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) grown on the West Coast is only moderately difficult to impregnate, the Rocky Mountain form of this species is very difficult to penetrate (11).[3] As a result, Douglas-fir is often used under conditions favoring rapid decay without first having received a preservative treatment. The only alternative in this instance is to select naturally durable timber for such uses. This cannot be done until the factors influencing the relatively high durability of Douglas-fir are understood.

Hawley et al (7) were among the earliest to note a relation between durability and chemical composition of wood. Several other investigators (14, 15, 18, 20, 25) have since concluded that the decay resistance of durable wood species can best be explained by considering the nature of their heartwood extractives.

The decay resistance of Douglas fir is intermediate between the very resistant and only moderately durable groups. A literature survey revealed that no effort had been made to explain this fact. Only one extractive component of Douglas fir, taxifolin, had been previously investigated for fungicidal activity. It was claimed to be a very weak fungicide (22).[4]

The specific purpose of this study was to investigate chemical extracts from Douglas-fir heartwood in an attempt to ascribe the reason for its relatively high durability to certain extractive materials. In order to do this, it was necessary to first prepare various Douglas-fir heartwood extracts, and then to divide these into less

[1] Entered in the Graduate Division, 1955 Wood and Wood Products Award competition. The award is sponsored annually by the Vance Publishing Corp., Chicago.

[2] Research Paper No. 12, Faculty of Forestry, University of British Columbia, Vancouver, B. C. Condensation of a thesis written in partial fulfillment of requirements for the M.F. degree granted the author by the University of British Columbia in 1955.

[3] Numbers in parentheses refer to literature cited.

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[4] This statement was not supported by the correct bibliographical notation. This misunderstanding was rectified through correspondence with the author, who referred to unpublished results of Rennerfelt. Correspondence with the latter revealed that only a cursory examination with taxifolin had been made.

complex groups. Following this, an assessment (bioassay) of each of these materials as fungicides was made.

Selection and Preparation of Material

A single codominant Douglas-fir tree growing on a fir-hemlock-cedar site on the University of British Columbia forest at Haney, B. C., was selected for investigation. It measured 1?.0 inches in diameter at breast height and had a total height of 104 feet. Its age, including a correction for stump height, was approximately 83 years.

Two four-foot bolts were bucked from the butt end of the tree immediately after felling. The butt end was preferentially chosen, since there is some evidence in certain other species to indicate that this portion is more durable than the top (1, 18). A young second-growth tree was selected, because work by Graham and Kurth (6) has indicated that heartwood material from this source contains a higher percentage of extractives than old-growth timber.

The heartwood from the first bolt was reduced to wood meal by grinding in a Wiley mill until it passed through a 20-mesh screen. The meal was then seasoned before leaching until its moisture content dropped to approximately 15 per cent.

Chemical Separation

Certain extraneous components of Douglas-fir heartwood have been investigated by Schorger (21) and Pew (15, 16). A systematic analysis of the entire extractive fraction has been made by Graham and Kurth (9). Their method was followed because it provided a complete extraction procedure, with subsequent subdivision into known components. An outline of this extraction procedure is presented in Fig. 1.

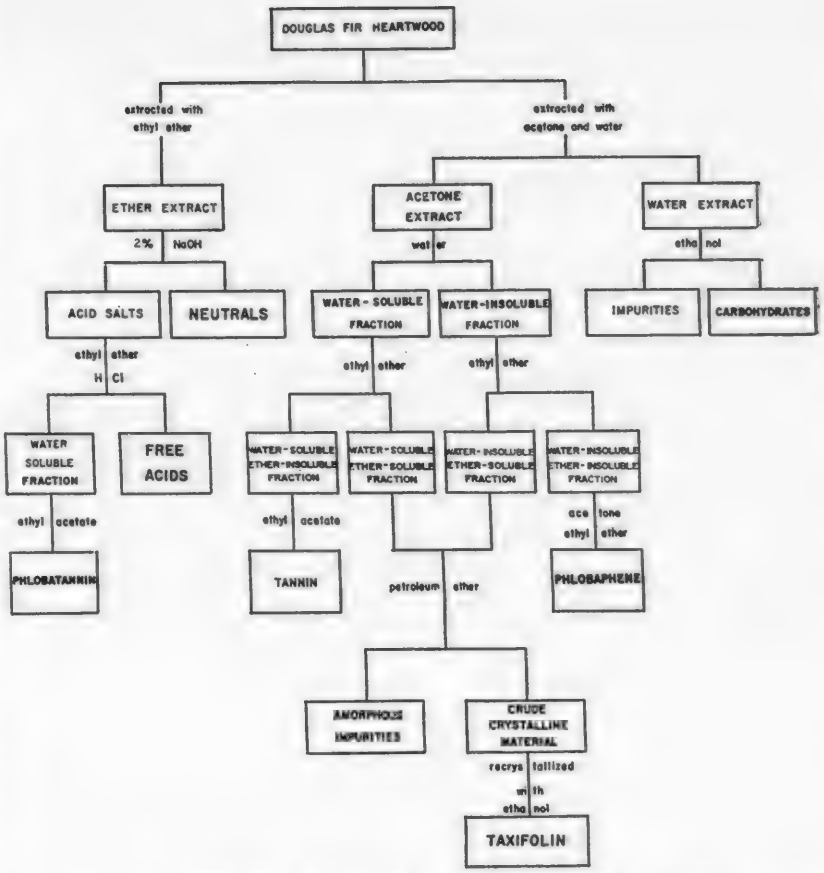

Fig. 1.—Extraction procedure for isolation of extraneous compounds.

Acetone Solubles: Division and purification of the acetone extract resulted in the isolation of two major fractions. One was a brown amorphous powder obtained from the water- and ether-insoluble portion of the acetone extract. This has been previously determined as a phlobaphene (9), which may be defined as a alcohol-soluble, water-insoluble condensation product of tannins (8). This phlobaphene fraction was highly insoluble in alcohol, acetone, and dioxane after isolation. Further condensation between molecules during purification may have resulted in this insolubility. The phlobaphene was not investigated in the following toxicity studies, since its insoluble nature prevented its proper impregnation into the substrates prepared for fungal growth.

The major portion of the acetone extract was obtained as creamy-white crystals of crude taxifolin. This material was first described by Pew (12, 13) and subsequently by Graham and Kurth (6). Its structure has been reported as 3, 5, 7, 3′, 4′—pentahydroxy flavanone (12, 13). This flavanone is readily oxidized to quercetin (5, 7, 3′, 4′ tetrahydroxy flavanol) (22). Since the former flavanone differs from quercetin only by two additional hydrogen atoms at the 2nd and 3rd positions (with a consequent loss of a double bond), it is commonly called dihydroquercetin.

The crude taxifolin prepared from the acetone extract melted with decomposition at 233°–236° C. Kurth et al (9) have since prepared a very pure dihydroquercetin melting at 238°–240° C.

Ether Solubles: Three fractions were obtained from the ether extraction: a group of neutral materials, a free-acid portion, and a tannin-like substance.

The neutral material probably contained a heterogeneous mixture of compounds. Its highly aromatic odor suggested the presence of the volatiles usually associated with Douglas-fir oleoresin. Schorber (17) investigated this fraction and found it to consist of a mixture of terpenes, predominantly *l*-α pinene and its derivative, *l*-α-terpineol. The remaining components in the neutral fraction have not been specifically identified, but probably consist of acids combined as esters, as well as high-carbon alcohols (sterols) (6).

The free acid portion was isolated as a dark-brown, tacky substance, having a consistency similar to taffy candy. This fraction has been reported to consist of an abietic-type resin acid in addition to several unidentified acids (6).

The red-brown amorphous powder, which was obtained by extracting the aqueous phase with ethyl acetate, had the properties of a phlobatannin, since it produced a red-brown precipitate when heated with dilute mineral acid. The precipitate from this reaction is termed phlobaphene, and thus phlobatannins are defined as phlobaphene-producing tannins (22).

Water-Solubles: The acetone-extracted sawdust was air-dried and subsequently leached with water at room temperature. Extraction at elevated temperatures was avoided, as this could result in a gradual hydrolysis of the cell wall itself (21). A small portion of the granular powder obtained was analyzed using paper chromatographic methods. The carbohydrate fraction was found to consist of polymers of galactose and arabinose, since only these sugars were detected

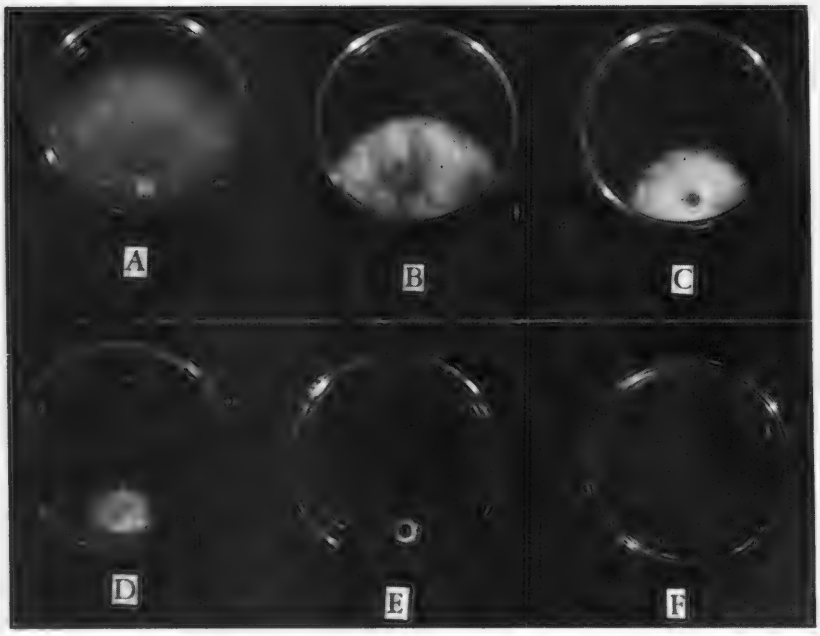

Fig. 2.—Effect of taxifolin concentration on growth of *Fomes annosus* in malt agar. A: control; B: 0.05%; C: 0.1%; D: 0.2%; E: 0.4%; and F: 0.6%.

after hydrolysis. A previous study of the hydrolyzate of the water soluble polysaccharide of Douglas-fir had revealed the presence of galactose (90%), arabinose (9%), and xylose (1%) (21).

Bioassay Method

These isolated materials were investigated for relative fungicidal activity by observing the effect of each component on the growth of wood destroying fungi. In order that direct comparisons between the various substances could be made, numerical expressions for their effectiveness were sought.

Malt Agar Procedure: Malt agar to which various extractive components were added was employed as a substrate for testing the reactions of wood destroying fungi. Its property of gelling quickly upon cooling allows it to retain water insoluble solutions in a dispersed state. Malt agar was used in preference to an aqueous nutrient medium, because two of the components to be evaluated were insoluble in water-miscible solvents.

Various concentrations of each extractive were added to 100-ml. quantities of Difco malt agar that had previously been sterilized. Weighed amounts of taxifolin and phlobatannin were added in the form of alcoholic solutions, whereas the acid and neutral fractions were first dissolved in ether. Alcohol had previously been used to apply water-insoluble substances to malt agar (14). Preliminary tests had revealed that ether exerted only a slight toxic effect. Malt agar solutions containing 1, 2, and 4 per cent ethyl alcohol or ether were prepared for control purposes.

The concentrations of material in the resulting malt agar solutions were expressed in grams per milliliter. The amount of chemicals added ranged between 0.01 g. and 1.00 g. Therefore, the per cent concentration of chemicals in 100 ml. of malt agar varied from 0.01 per cent to 1.00 per cent.

Eight small Petri dishes (50 mm. diam.) could be poured with each 100 ml. of malt agar solution. *Fomes annosus* (Fr.) Cke. and *Lentinus lepideus* Fr., both commonly found on Douglas-fir timbers, were selected for use as test fungi[5]. Thus for each concentration of a given chemical, four Petri dishes were available for inoculation with a specific organism.

It was not anticipated that the water-soluble carbohydrate fraction would inhibit fungal growth. This was sterilized separately, and then added to plain agar in amounts up to 2 per cent. It served as a replacement for the malt which was used as a nutrient in the other tests.

It was desirable to compare the results obtained using the wood extracts with a water-soluble chemical commonly employed as a wood preservative. Therefore, a parallel experiment, consisting of zinc chloride as the toxicant, was set up.

Inocula for all dishes were taken from the margins of mycelium grown on malt agar for an 18-day period. Each piece of inoculum was cut with a cork borer to insure uniform size.

[5] Pure cultures of these organisms were originally obtained from the Wood Pathology Unit, Vancouver Laboratory, Forest Products Laboratories of Canada.

The inoculated dishes were incubated at 25° C. until the plates were covered with mycelium, or until the agar started to crack through desiccation. The radial growth of the organisms was measured and recorded at approximately two-day intervals during this incubation period. Fig. 2 shows a series of Petri dishes containing successively higher concentrations of taxifolin, which were inoculated five days previously with *Fomes annosus*.

It has been well established that a steadily decreasing amount of growth is obtained as the concentration of fungal inhibitors in malt agar is increased. Bateman (2) found that a straight line could be obtained if the logarithm of the per cent retardation of growth was plotted against the logarithm of per cent concentration of fungicide. The data collected in this study were analyzed after the method of Bateman, in order to determine the chemical concentration at which no fungal growth would occur. Schmitz (16) has defined this specific concentration as the Total Inhibition Point (T.I.P.)

The data obtained from measurements of fungal growth were first averaged for each individual extractive concentration, time, and organism. Growth curves were obtained when the resulting figures, representing the means of four measurements, were plotted on co-ordinate paper. Representative growth curves of *F. annosus* on malt agar containing different concentrations of taxifolin are presented in Fig. 3.

Percentage retardation of growth was calculated from these curves by considering the radial distance a fungus grew in covering the control plates as zero per cent retardation. Fig. 4 presents the logarithmic relationship of per cent retardation of growth of *F. annosus* on malt agar cultures containing different concentrations of taxifolin. The point at which the extrapolated curve reached 100 per cent retardation was considered as the T.I.P.

Wood Block Procedure: Natural conditions of decay can be more closely approximated by exposing wood blocks to decay fungi under controlled conditions. The soil-jar method of Leutritz (10) was employed in this study to test the relative resistance of wood blocks from which certain components had been removed by extraction with neutral solvents. The degree of fungal decay was determined by the weight losses suffered by the wood blocks after an incubation period of two months.

A radially sawn board was taken from the original test bolt for the preparation of wood block samples. All samples were prepared from a band of

outer heartwood which was a uniform distance from the sapwood. This nullified possible variations in durability due to different radial position in the stem. Each sample block measured 0.6 x 1.5 x 4.0 cm., the smallest dimension being parallel to the longitudinal axis of the wood fibres.

The blocks were leached in either acetone, ether, or water to correspond to the preceding chemical analysis of the Douglas-fir wood meal. In order to obtain an initial equilibrium weight, the samples were conditioned in a constant temperature-humidity chamber to a moisture content of 30 per cent. After superficial flame sterilization, they were placed in soil jars that had been inoculated a month previously with *Poria incrassata* (B. & C.) Curt. or *Lentinus lepideus*. Five replications were provided for each extractive treatment and fungus involved. Controls employing unextracted wood blocks were also established.

When the incubation period of two months had elapsed, the blocks were removed, brushed free of excess mycelium, and oven dried. The weight losses suffered by the test blocks while undergoing decay in the soil jars were expressed as percentages of the calculated original oven-dry weights. The percentage loss in weight of the extracted specimens was compared against the controls using Student's "t" test. The resulting values for "t" were evaluated at the 5 per cent confidence level.

Bioassay Results

Malt Agar Procedure: Results of the malt-agar tests are summarized in Table 1. Taxifolin was definitely the most toxic wood extractive investigated, although it did not approach the effectiveness of zinc chloride as a fungicide. Nevertheless, taxifolin and the other extraneous materials in Douglas-fir could eventually prove superior to zinc chloride as wood preservatives in certain instances. Due to its water-soluble properties, the salt leaches out of treated timbers under wet exposure conditions (8). The water-insoluble nature of the fungicidal Douglas-fir extractives permits more permanent protection than is afforded by zinc chloride.

Table 1.—CONCENTRATION OF CHEMICALS IN MALT AGAR NEEDED TO COMPLETELY INHIBIT FUNGAL GROWTH AT 25° C.

Organism	Chemical or Extractive Tested	T.I.P.*
Fomes annosus	taxifolin	0.45
	phlobatannin	1.3
	neutrals	1.4
	free acids	1.1
	zinc chloride	0.16
Lentinus lepideus	taxifolin	0.70
	phlobatannin	1.6
	neutrals	4.7
	free acids	2.0
	zinc chloride	0.08

*Total Inhibition Point.

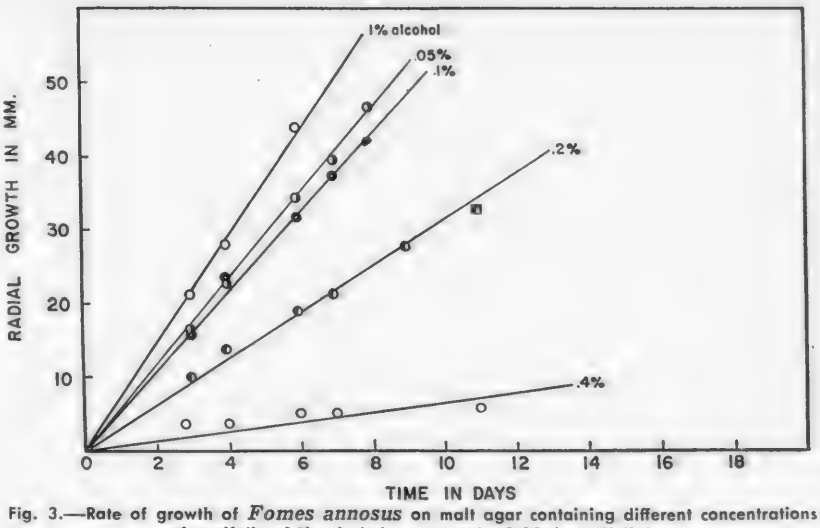

Fig. 3.—Rate of growth of *Fomes annosus* on malt agar containing different concentrations of taxifolin. 1% alcohol = control (0.00% taxifolin)

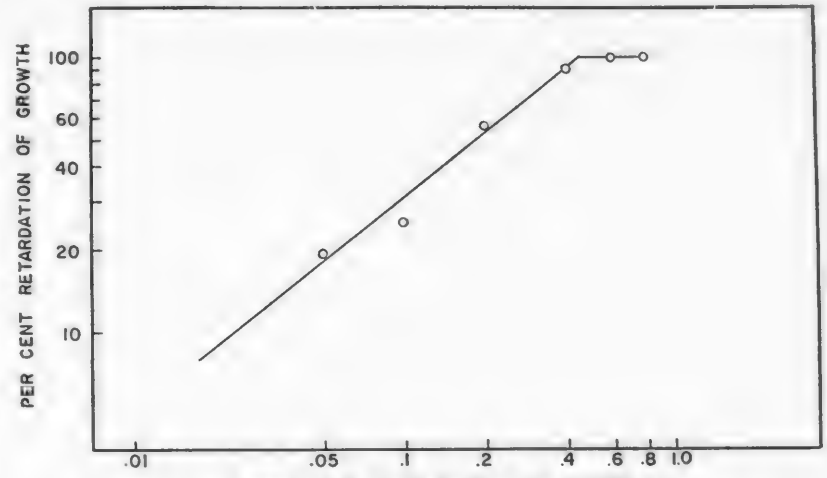

Fig. 4.—Retardation of growth of *Fomes annosus* on malt agar containing different concentrations of taxifolin

The carbohydrate fraction apparently did neither support nor hinder fungal development when added to plain agar. A nearly transparent mycelium was developed at the same rate for all concentrations of carbohydrate included in the agar. Since the hydrolyzate of the water extract of Douglas-fir has been identified as 90 per cent galactose, it can be concluded that the carbohydrate is largely a galactan (21). Galactans, unlike mannens and pentosans, are quite resistent to attack by wood-destroying fungi (3).

Wood Block Procedure: The average weight losses obtained for each set of five samples are included in Table 2. The acetone- and ether-extracted samples exposed to the action of *L. lepideus* suffered nearly equal and significantly higher weight losses than the controls. The results suggest that the three weakly toxic components investigated as sub-divisions of the ether extract may exert a combined fungical action equal to that of taxifolin. The water-extracted blocks, although not varying significantly from the controls, nevertheless show a somewhat higher weight loss. This was probably due to the removal of some water-soluble tannin substances along with the carboyhydrate material.

The reductions in weight obtained with *Poria incrassata* were not statistically significant when analyzed with the "t" test. A longer incubation period may be required with this fungus in order to obtain meaningful results,

Table 2.—AVERAGE WEIGHT LOSSES OF EXTRACTED WOOD BLOCKS IN SOIL JARS (2-MONTH INCUBATION)

Organism	Extractive Treatment	Av. Wt. loss*
Poria incrassata	Acetone	25.3
	ether	24.7
	water	29.7
	none	23.0
Lentinus lepideus	acetone	52.2†
	ether	51.8†
	water	44.7
	none	37.6

*Per cent of original oven-dry weight.
†Significantly different from unextracted blocks (5% level).

since the weight losses amounted to only half those of the samples infected with *Lentinus lepideus*.

Discussion

Some comparisons can be drawn between taxifolin and other phenolic extractives occurring in the family *Pinaceae*. Rennerfelt has determined the toxicity of pinosylvin by the malt-agar method (14). By plotting his data for *Fomes annosus*, a T.I.P. of 0.06 per cent is obtained. Pinosylvin was first isolated from Scots pine (*Pinus sylvestris* L.) and has since been found in a number of the hard pine (Diploxylon) group. Its monomethyl ether has also been isolated, not only from the hard pines, but from the soft pine (Haploxylon) group as well (26). This monomethyl ether of *Pinus* acts as a weak fungicide, since concentrations slightly in excess of 1 per cent are required to completely inhibit growth of *F. annosus* (14).

In addition to both being phenolic in character, pinosylvin and taxifolin have certain other similarities. Both substances are soluble in ethyl ether only after they have been removed from wood with acetone or alcohol. Erdtman (22) has attributed this phenomenon to ether-insoluble "membrane substances" which envelop the phenolic molecules so that they are made inaccessible to ether. Extraction with alcohol or acetone apparently dissolves both the phenolic and ether-insoluble substances, allowing the taxifolin or pinosylvin to be subsequently soluble in ether.

Therefore, there is some question as to whether taxifolin and similar phenolic compounds isolated by chemical means are identical with those occurring naturally in the wood. Their chemical nature and physical availability may differ when isolated. Further evidence to support this view arises when the insecticidal properties of taxifolin and pinosylvin are considered. Both compounds have been shown to be highly toxic to the West Indian dry-wood termite (*Cryptotermes brevis* Walker) (24). Wood blocks submerged in a 0.05 per cent taxifolin solution for ten minutes have remained free from attack for more than 42 months (23). The taxifolin present naturally in Douglas-fir wood apparently provides no protection whatsoever, since this species is readily attacked by the tropical dry-wood termite. The reason for this discrepancy may be one of availability. A wood block soaked in a taxifolin solution would present an even distribution of pure compound to an attacking agency. The naturally occurring substances is probably distributed unevenly, and may be largely inaccessible to wood-destroying insects by existing in an intimate form with other materials.

Taxifolin has been reported to exist naturally in an average concentration of about 1 per cent in Douglas-fir heartwood (12, 13). The combined concentration of pinosylvin and its monomethyl ether in pine heartwood amounts to about 0.8 per cent of the dry weight of the wood (15), with the less toxic pinosylvin monomethyl ether being present in amounts three to four times that of the parent pinosylvin (22). Douglas-fir and Scots pine have been classed in the same natural durability group by Smith (23). This may be due in part to the fact that they both contain a nearly equal concentration of fungicidal phenolic compounds.

Conclusion

The specific concentrations of wood extractives needed to inhibit growth in malt agar should not be interpreted as representing the amount of substance that must necessarily be present in wood to prevent fungal growth. Rather, they serve to indicate the relative importance that a component may play in protecting wood from decay. On the basis of the data collected in this study, it appears that taxifolin may be largely responsible for the moderate decay resistance of Douglas-fir.

Acknowledgments

The author wishes to acknowledge the encouragement and helpful criticisms offered by Dr. J. W. Wilson and Dr. D. C. Buckland, Faculty of Forestry, U. of British Columbia, under whose direction this work was undertaken. The free use of facilities at the Vancouver laboratory, Forest Products Laboratories of Canada, is gratefully acknowledged. Special thanks are due to Dr. J. A. F. Gardner, Head, Wood Chemistry Section, and the other members of the staff for their suggestions and assistance.

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What's New in Veneer Splicing Techniques[1]

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Summarizes conventional methods of veneer edge gluing and points out the need for new techniques and improved methods, spurred by the tremendous growth of the plywood industry and the need for conservation of forest resources. Continuous edge gluing brought out the need for improvements in techniques of preparing and handling veneers prior to the edge gluing process. Concludes with future prospects for automation, starting from the green end.

CONVENTIONAL METHODS of veneer edge gluing which have been developed and are in general usage today must be reviewed before attempting to describe what is new in veneer splicing techniques. Thus, by contrast, newer techniques may be more closely evaluated.

Naturally, the departure from old established methods and the search and acceptance of new techniques by the veneer and plywood industry depends upon the economic urgencies involved and the means available by which to bring about change.

The depletion of old growth peeler logs has forced the utilization of different, if not poorer, grades of timber, the characteristics of which require and suggest new techniques.

In review, gummed paper tapes have long been and are still presently being used to hold veneers in register edge to edge until made into plywood. The subsequent removal of this tape increases sanding costs appreciably.

This taping method is accomplished by forcing the veneers into juxtaposition edge to edge while the stock travels, parallel to the grain, under a heated taping head. It is obvious that this method is best suited for wide stock requiring only one pass to produce a standard 52-inch wide panel.

Tapeless splicing, a modification of the taping process, consists of spreading glue on the spliced edges of the veneers and subsequently setting the glue by the application of some source of externally applied heat. A pressure device crowds the veneers, edge to edge and in register while being transported through the press, also in the direction of the grain. The main advantage attained is the elimination of the paper tape.

Both methods waste wood in the form of trim, which usually amounts to about a 10 to 15 per cent loss.

Narrow stock, requiring a multiplicity of passes to the standard panel, is apt to be split before completion of the panel due to repetitive handling, thus contributing to further losses in the form of reclips. Nevertheless, both tape and tapeless methods are suited to very thin veneers and small production runs.

Variety of Problems

The necessity for utilizing increasing quantities of narrow stock naturally suggested the passing of veneers edge to edge continuously in a direction at right angles to the grain, thus markedly raising the rate of production as compared to the previously described intermittent longitudinal flow of stock. But veneers flowing at right angles to the grain impose a problem of holding the edges under pressure and in register while being glued; the difficulty mounts rapidly as the thickness of the veneers is diminished.

It was found that bending the veneers at right angles to the grain around a revolving drum was a great aid in holding the edges in register because of the stiffening effect. Attempts have been made to bend the veneers longitudinally to conform to the surface of a cylinder or cone but with mediocre success.

The circular drum wheel, which has been and still does have some usage in the fir industry, is an example of the circular device, the veneers wrapping around the drum at right angles to the grain. In this device, the veneers are held tightly to the surface of the revolving drum by means of driven steel bands which travel at a slightly greater speed than the surface of the drum. The glue is set by the conduction of heat into the glue line from contact with the heated drum and external heat lamps.

There are some disadvantages inherent in this method:

1. Excessive heat is stored in the wood and this surplus heat should be removed by some form of cooling system before the clipped panels may be stacked; but this is not always done.
2. The drum is heated to a temperature above the char point of wood, which sets a limit to production for any given thickness of veneer. Thick veneers as compared to thin veneers must be run more slowly and at a lesser temperature in order not to char or scorch the surface of the panels or to case-harden the surface of the veneer.
3. Considerable time is required to bring the drum up to working temperature from a cold start, and in case of needed repairs, a considerable time must elapse before workmen may enter the heated area.
4. To glue eight-foot stock, power to the order of 100 to 140 KW is required to energize the electrically heated elements and the cooling fans.
5. Since the panels are glued while held in the curved state, some undesirable strains are set up in the wood structure when subsequently returned to a flat plane.

Wood ranks low in the scale of heat conductivity and any gluing operation, which is largely dependent upon wood as a medium to conduct heat into the glue line, must operate at high ambient and contact temperatures if practical production rates are to be approached. In turn, such high temperatures to the order of 350° F. impose adjustment and maintenance problems due to the appreciable expansion of the metallic parts composing the press structure.

Continuous veneer edge gluers have been devised to maintain the veneers in a flat plane while being bonded. However, these still embody substantially the same techniques as the drum type, mainly because of dependence upon wood as a conductor of heat in-

[1] Presented at Session VII, Glues and Gluing, FPRS Ninth National Meeting, June 21–24, 1955, in Seattle, Wash.

The Author: J. W. Mann, an electrical engineer, spent 30 years teaching in public schools. Since 1939 he has been associated with Mann–Russell Electronics, manufacturers of industrial electric r. f. generators and associated presses. Mann is the co-holder of 20 patents related to dielectric heating.

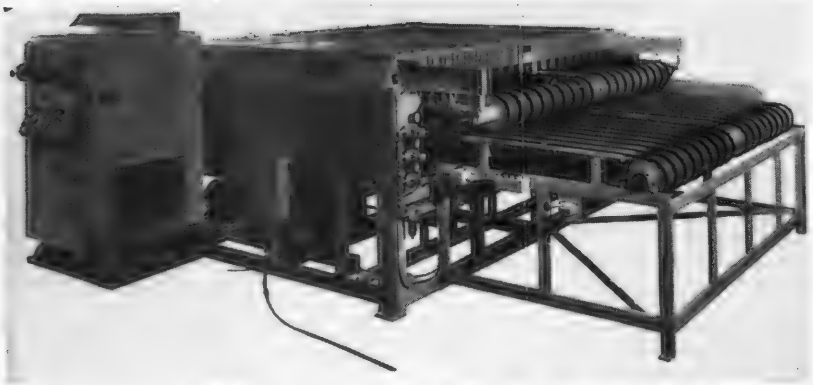

Fig. 1.—Infeed end of 10-foot electronic veneer edge gluer showing operator position and controls, including remote control of variable speed drive motor.

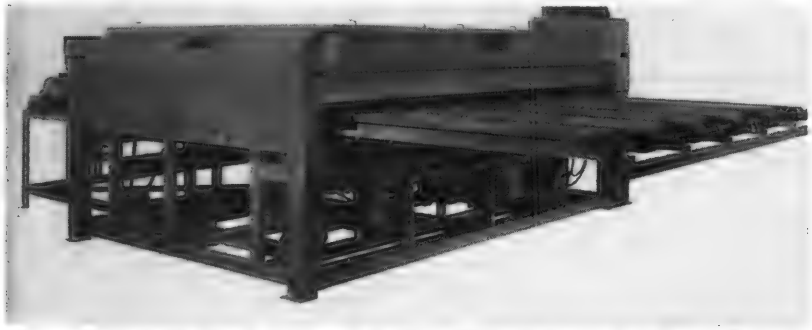

Fig. 2.—Outfeed end of 10-foot electronic veneer edge gluer with 6-foot flat belt conveyor table to which the single sheet dry clipper is attached at the extreme outboard end (clipper not shown).

to the glue line from some exterior source.

This review brings into prominence two components which have long delayed new efficient gluing techniques, i.e., the limited types of available glues and the inefficient means of applying heat to the glue line.

New Techniques

During World War II, the urgent and growing need for glued wood products created a heavy demand for new and better glues to augment and supplant those long in common use. Thus the chemist was stimulated to search for synthetic glues endowed with quick-setting and moisture-resistant properties. Out of this search came the four basic synthetic glues now widely used: ureas, resorcinols, melamines, and phenols.

The ureas polymerize at comparatively low temperatures but are only highly resistant to moisture. On the other hand, the remaining three, especially the phenols, set up at higher temperatures and are classed as water-proof glues.

Almost simultaneously, an exciting discovery evolved from the field of physics. These same synthetic glues, when catalyzed, react almost instantaneously when placed in a high frequency electromagnetic field of force. Here was a combination from which a new gluing technique could be constructed.

Physicists and radio engineers have long known about the heating effect of radio frequency electromagnetic fields in relation to dielectrics. The generators and transmitters and the antennae systems used in communications were also highly perfected.

But when these generators were converted for use in heating dielectrics, they were found to be quite unstable. It required a lot of work to evolve a sufficiently stable generator and then it required a lot more to design suitable electrodes which would function within the confines of a metal framework and internal mechanism of a continuous veneer edge gluing transport and pressure means.

There are some specific properties which this high frequency field of force possess which make possible the radical improvement in the technique of veneer edge gluing:

1. A dielectric, such as glue when subjected to a suitable h.f. field, may be heated to a high temperature internally, while the electrodes themselves remain quite cool.

2. The h.f. field is selective in that it fringes into and seeks out the wet glue lines and shuns the dry wood, especially if the glue lines lie substantially parallel to the field lines of force. Upon the latter phenomenon is based the patented process known as "Parallel Bonding".

3. As a result, the glue lines are raised rapidly to a much higher temperature than the adjacent areas of wood and the glue sets up almost instantaneously. When the glue is under pressure as is the case in edge gluing, the momentary peak temperature may rise well above 212° F. while the wood remains relatively cool.

4. The wood mass itself may only show a rise in temperature of 5° to 10° F. during the cycle required to set all the glue.

The advantages of the new techniques made possible by combining the properties of the new synthetic glues and h.f. are:

1. The cooling cycle may be eliminated because little heat energy is stored in the wood, thus saving equipment, space, and power.

2. The h.f. electric energy is converted to heat energy within the body of the dielectric itself; hence production rates need not be reduced because of a shift to thicker veneers.

3. Little heat energy is lost to the press structure and conveyor mechanism and distortion due to expansion is of no concern.

4. Only a few minutes of warm-up time are required to start production. No heat lag remains to interfere with immediate repairs or adjustments to the equipment; maintenance is easy.

5. Power requirements are low. comparatively speaking, only 15 kw input being required to power an 8-foot electronic edge gluer as compared to the previously mentioned 100 to 140 kw requirement for the steam or electrically heated press.

6. The system of electrodes lends itself readily to flat plane operation and eliminates glued-in stresses.

The rate of production inherent in the electronic veneer edge gluer is at present limited by the rate at which stock may be prepared and fed to the press. Some test runs have proven that the glue sets up at speeds of 50 feet to 60 feet per minute, which offers a challenge to do something about the preparation and handling of stock; this is currently limited to the human ability to feed the machine with veneer.

The advent of the continuous veneer edge gluers has also emphasized some past deficiencies in the preparation of stock. Errors in machining are cumulative as each succeeding piece is glued edgewise to the preceding piece. Wedge-shaped stock is a problem causing cumulative "skewing" and the introduction of compensating wedges is a poor corrective measure.

Splicing is an almost essential step in the preparation of the stock prior

to edge gluing. The splicer must be capable of producing near perfect straight edges—neither concave, convex, nor sniped. The edges should be squared with the faces and knife marks should not be fewer than 16 per inch for face stock.

Even though the splicer fulfills the above specifications, it can only do so if the stock is pressed perfectly flat over its whole area during the splicing operation. (Note that the veneers will subsequently be completely flattened during transport through the edge gluer.) At present the usual batch practice consists in gripping a bundle of random width veneers along a narrow portion of the width, even though the individual veneers may be heavily "end skirted" or "blistered". Such veneer when flattened can hardly present perfectly straight edges each to each. The results are open splices, overlaps, degraded panels, and waste.

Furthermore, preparatory to splicing each bundle must be shaken down and unless the operators exercise constant vigilance, some veneers in the package may be so displaced as to come out only partially spliced and glue spread.

Of course, the faulty pieces, unless thrown out by the lay-up operator, produce a chain reaction of more fall downs and waste.

The electronic edge gluing press itself embodies some unique features: it makes full use of frictional forces which are of primary importance, governing the design of the moving parts. For this reason thousands of roller ball bearings go into the construction of the electronic edge gluers, conveyors, and pressure means.

Veneers are transported between superimposed endless rubber V belts, the contact surfaces of which are coated with glue-repellant facings. Each belt rides on precision roller bearings which are supported in racks, lengthwise of the travel. The lower tractor-supporting frames float on transverse hose pressure means capable of individual adjustment to suit various types and thicknesses of veneers.

In the drive tractor, the multiplicity of rubber V belts are stretched as in a sling shot, opposing the resilient force of compression produced by the driven stock pushing against the rubber belts of the retarding tractor section. Thus, resilient edge pressure is maintained during the passage of the glue lines through the electric field.

To prevent the release of edge register pressure, the drive tractor and the retarding tractor are intermeshed at the point where the joints leave one to enter the other section.

The crowder tractor closes the veneers very gently edge to edge before they enter the drive section and are fed by roller chain from the lay-up section. Any overlapping and crushing of veneer is at a minimum since the chain's friction is low, relative to that of the V belts of the drive section.

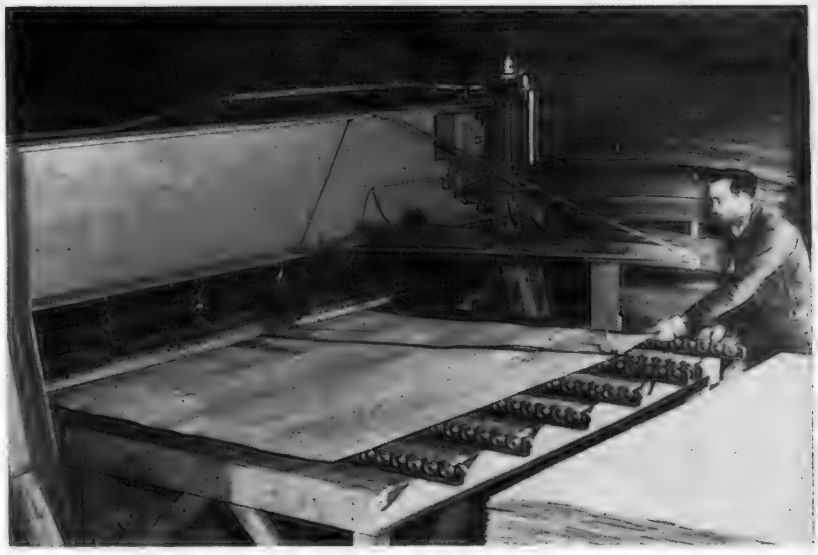

Fig. 3.—Edge-glued stock being clipped to required sheet width in plant of M and M Woodworking Co., Lyons Plywood Division, Lyons, Ore.

Consideration must also be given to types of glue and the amount of spread. Excessive "squeeze out" is detrimental for a number of reasons. The type and quantity of catalyst is of importance. A glue representative should be consulted in these matters; his advice will prove valuable.

What's Ahead

If we are to further mechanize edge gluing, we must think boldly. Perhaps the immediate future holds these changes:

1. Development of a fast single sheet double cutterhead splicer-glue spreader which will hold veneers flat while cutting parallel edges.

2. Development of a double cutterhead splicer-glue spreader which will take flitches of veneer for multiple preparation and discharge into a hopper for automatic feeding to the electronic veneer edge gluer.

3. Development of clipping procedures in the green tables to secure a standard width for veneers rather than random widths; at least to clip not over 18 inches in width and edge glue all veneer produced to more uniform panels.

These techniques are in the making and, depending on the quality of logs available, will come sooner or later. As it looks currently, they will be here soon.

Discussion

John Reno (Pacific Lumber Co.): Is there any illustrated literature on r.f. edge gluers?

Mr. Mann: Yes. This literature is available.

Frank Holland (Consultant): If the operator should load several narrow pieces of veneer close together on the machine, a larger number of glue lines would pass between the electrodes at any given instant. If this occurs, does some form of automatic load control vary the power as required? What is the disposition of the electrodes?

Mr. Mann: Stray field electrodes are located 2-½ inches apart with pressure chains between each electrode. We tried feeding a large number of glue lines through the machine by edge gluing consistently narrow veneers at a high speed with no difficulty.

Dr. Ben Bryant (College of Forestry, U. of Washington): At the FPRS Veneer and Plywood Committee this morning, we spoke of the needs of industry in the veneering field. Mr. Mann's interest in the problem of splicing veneers properly so that good edge gluing can be accomplished by means of r.f. is illustrative of the overlapping interests of these standing committees.

Everett Reichman (Simpson Logging Co.): Are you able to glue thinner veneer with this edge gluer than with the drum type? If so, what minimum thickness can be edge glued?

Mr. Mann: We can go to 1/24-inch veneer and under special conditions we can glue 1/28-inch veneer. Certain frictional forces had to be overcome to prevent crushing and overlapping of the thinner veneers. Now we are able to keep them from buckling across the grain.

Air Drying of Ponderosa Pine Lumber in Arizona[1]

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and

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Studies of air-drying ponderosa pine in Arizona are described and results presented. The data includes the periods required to air-dry 4/4 common, 8/4 common, and 6/4 shop grades to 10 per cent moisture content; losses in grade and value during air drying and planing; and losses caused by the lack of pile roofs.

Introduction

THE CLIMATE OF ARIZONA favors rapid air drying to a relatively low moisture content. Some mills cutting ponderosa pine rely on air drying to dry all grades of lumber for planing, molding, and shipping. Other mills kiln dry select and shop grades green from the saw but air dry common.

The air-drying experiments reported herein were conducted at Flagstaff and Snowflake,[3] Ariz., at plants owned by Southwest Lumber Mills, Inc. There were no dry kilns at these plants. Most of the lumber was air dried, but some upper-grade lumber was shipped to another company mill for kiln drying.

The study was conducted by the Forest Utilization Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo., and the Forest Products Laboratory, Madison, Wis., in cooperation with the Southwest Lumber Mills, Inc., Phoenix, Ariz.

Objectives

Principal objectives of the study were (1) to determine the time required to air dry 4/4 and 8/4 common and 6/4 shop lumber to a moisture content of 10 per cent during the different seasons of the year; (2) to determine the minimum moisture content attainable during each season; (3) to measure drying defects and to interpret them in terms of material and dollar losses; and (4) to measure the drying defects that occurred in the boards of the two top courses of the piles, largely because pile roofs were lacking, and to interpret them in terms of material and dollar losses. Additional objectives were to determine the effect of two sticker thicknesses, 2 inches and 25/32 inch, on drying time and on defects that developed during the air drying of 8/4 common; to ascertain the relative amounts of drying defects that occurred in 4/4 and 8/4 common; and to evaluate the effect of moisture content on the amount of degrade during planing.

Experimental Work

Scope: Seventeen piles of lumber and 51 unit packages were used in the tests, which involved a total of 79,000 board-feet. There were 7 piles of 4/4 common, 6 piles of 8/4 common, and 4 piles of 6/4 shop. Nine piles were erected at Snowflake and 8 at Flagstaff.

Material: The lumber was obtained from the green chain at the Flagstaff mill and from the sorting chain at the Snowflake mill. The 4/4 and 8/4 lumber was graded as No. 3 common and better and was 12 inches wide and 8, 10, 12, 14, and 16 feet long. The 6/4 shop was random width, most of it 16 feet long. The 4/4 lumber at Snowflake was produced by resawing 8/4 boards. The 4/4 and 8/4 common lumber averaged about 80 per cent heartwood. The 6/4 shop averaged 28 per cent heartwood. The average green or initial moisture content of the common lumber was 51 per cent, that of the shop lumber 122 per cent.

Unit Packages: Unit packages 4 feet wide and 16 feet long were stacked three to a pile. In height the packages varied from 2 feet 9 inches to 4 feet 6 inches, depending on the thickness of the boards and the stickers as well as on the number of lumber courses. The packages were box piled, the edge tiers consisting of boards 16 feet long (Fig. 1). The shorter boards were placed in the two central tiers so that one end was always flush with one end of the package. The boards were piled edge to edge (Fig. 2).

Stickers were 25/32, 1-1/16, and 2⅛ inches thick, and from 2½ to 4 inches in width. Five tiers of stickers were used. At Snowflake the tiers were roughly 2, 6, 6, and 2 feet apart; at Flagstaff, about 3½, 4½, 4½, and 3½ feet. The unit packages of 4/4 common lumber at Flagstaff had extra tiers of stickers in the first four courses to provide support above the bunks of the straddle trucks and the forks of the forklift trucks (Fig. 2). The unit packages were built without sticker guides, but a measuring stick was used to position the tiers.

Lumber Piles: Most of the test piles consisted of 3 test unit packages and a dummy package consisting of lumber not in the tests. The piles of 8/4 lumber at Snowflake that were built with 2-inch stickers were the only ones that did not contain dummies. The dummy

[1] Presented by title only at Session II, Wood Drying, Ninth National Meeting, FPRS, June 21–24, 1955, in Seattle, Wash.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] This plant was dismantled in the spring of 1954.

The Authors: Edward C. Peck is a graduate of Sheffield Scientific Institute, received M.F. degree from Yale Forestry School. Since joining the Forest Products Lab in 1921, Peck has conducted studies in bending, physical properties, and seasoning of wood.

E. S. Kotok received B.S. from U. of California, M.S.F. from U. of Michigan. He joined the U.S. Forest Service in 1947, was named to his present position in November 1955. Kotok is a member of the FPRS Wood Preservation Committee.

Lincoln A. Mueller, a graduate of the U. of Minnesota School of Forestry, joined the U. S. Forest Service in 1933. He is a member of FPRS, SAF, and AWPA.

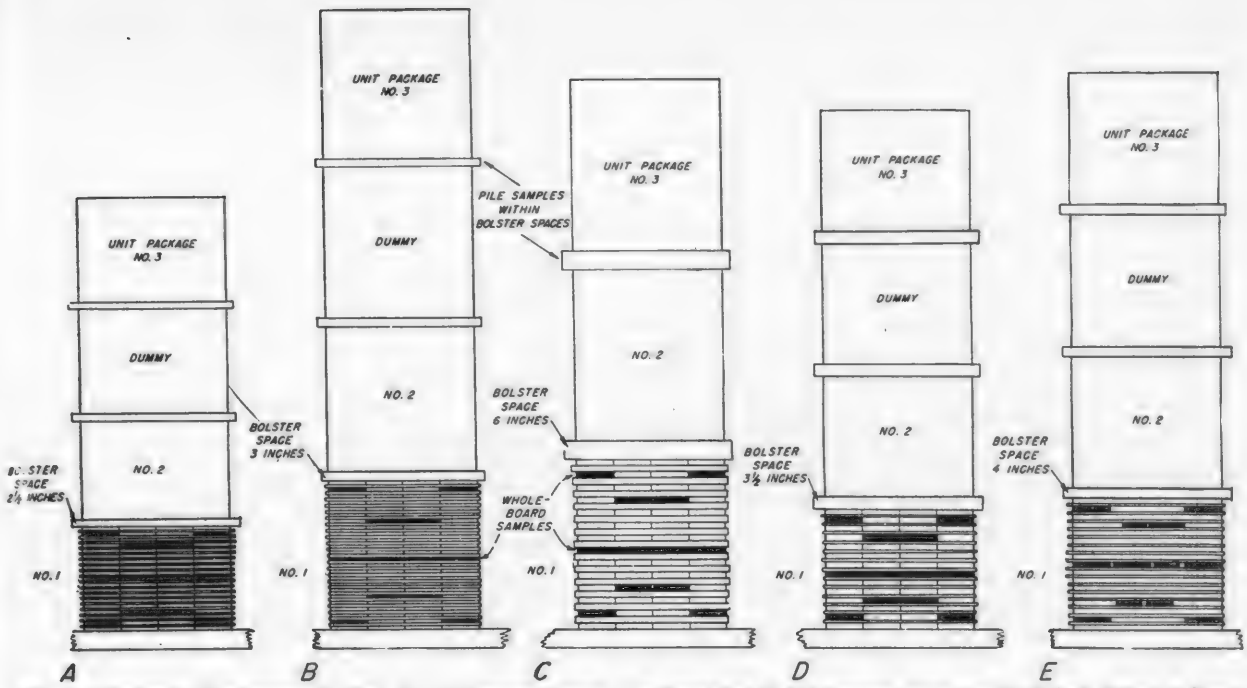


Fig. 1.—Diagrams of experimental piles. A: 4/4 common lumber on 25/32-inch stickers at Snowflake; B: 4/4 common lumber on 1-inch stickers at Flagstaff; C: 8/4 common lumber on 2-inch stickers at Snowflake; D: 8/4 common lumber on 25/32-inch stickers at Snowflake; E: 6/4 shop lumber on 1-inch stickers at Flagstaff.

unit packages contained lumber identical with that in the rest of the pile. The test unit packages were placed at the bottom, next above the bottom, and at the top of the pile (Fig. 1). The piles were built with forklift trucks.

The piles were placed on foundations of the fixed-beam type. The pile foundations at Snowflake consisted of two beams about 15 feet apart and about 16 inches above the ground. The foundations in the yard at Flagstaff consisted of four fixed beams placed roughly 3½, 9, and 3½ feet apart and about 1 foot above the ground. The runways between the foundations were surfaced with gravel at Snowflake (Fig. 3) and were planked at Flagstaff. At both Flagstaff, and, for the 8/4 lumber, Snowflake, central supports were provided for the piles (Fig. 3). The piles of 4/4 lumber at Snowflake had two supports over the 14-foot span between the foundation timbers.

The piles were placed 2½ feet apart in an inner row of the yard and were shielded at each end by other piles. They were not roofed.

Samples: Three kinds of samples—pile, benchmark, and whole-board—were used to check rate of drying as the tests proceeded. The pile and whole-board samples were placed in the lumber pile. The benchmark samples were suspended beneath a shed roof and fully exposed to the air of the yard (Fig. 4). Pile and benchmark samples were 3½ feet long, whole-board samples 16 feet long. Sixteen pile samples were used in each pile of the first set and 8 in each pile of the other sets. They were placed on stickers in the bolster spaces just above the bottom unit package and just below the top unit package. Bolster spaces were so adjusted that the pile samples were spaced just as the boards of the pile were (Fig. 1). There were 12 whole-board samples in each unit package, or 36 for each pile. Fig. 1 shows the locations of these samples. Six benchmark samples of each kind of lumber in a set of piles were exposed in sheds (Fig. 4).

Fig. 2.—Unit package of 4/4 No. 3 common and better at Flagstaff, showing extra short tiers of stickers.

The benchmark samples supplied drying data that indicated the fastest drying that was possible under the prevalent atmospheric conditions. These data are not included in this report. They also provided data on surface checking, and supplementary data on the minimum moisture content values attainable during the different months. The pile samples provided drying time data for the atmospheric conditions within the lumber piles, and data on surface checking. The whole-board samples gave values for initial and final moisture content and data on surface and end checking. The whole-board samples also yielded data

Fig. 3.—Placing a pile sample in position between unit packages Nos. 1 and 2 while standing on the gravelled runway at Snowflake. The pile is composed of 8/4 lumber with 2-inch stickers.

Fig. 4.—Benchmark samples of 6/4 shop lumber suspended within an open shed at Flagstaff.

on degrade, since they were graded green, air dry, and, in the case of the 4/4 lumber, after planing. Finally, the whole-board samples gave information on the percentage of heartwood and sapwood and on the character of the grain.

Tests and Measurements: All samples were weighed and tested for moisture content by the oven method to get moisture content values at the start, during, and at the conclusion of the air-drying experiments. Surface checks and end splits were measured in inches of length. Percentage of heartwood and the character of the grain were estimated. All lumber was tallied and graded when green and after air drying[4]. Most of the 4/4 lumber was also tallied and graded after it was planed.

Procedure: The first step in putting up a set of study piles was the selection of the material. The green lumber was then graded and representative boards were selected for the preparation of the samples. In the random-width 6/4 shop, no sample board was greater than 12 inches wide. The whole-board samples were numbered and weighed and the character of the grain, the percentage of heartwood, the grade, the total inches of surface checks on both faces, and the length of the longest end split were recorded.

The pile samples were cut from chosen boards together with 1-inch sections that were weighed, ovendried, and reweighed to determine their moisture content. The samples were end coated, numbered, weighed, and inspected as were the whole-board samples, except that they were not graded.

[4] Lumber was graded by Jack Hahn of Southwest Lumber Mills, Inc.

Each board in the piles was numbered and its exact position in the unit package recorded as the package was built.

When the pile was erected the pile samples were placed in the bolster spaces, the benchmark samples were suspended in an open shed, and the air drying was considered to have started. Then the benchmark and pile samples were weighed periodically and examined for surface checks and end splits. The sample weights gave moisture content values that were used to determine drying rates.

When the piles were taken down, the whole-board samples were weighed and a section was cut from each for the determination of moisture content by the oven method. The total length of surface checks and the length of the longest end split were measured. The whole-board samples were also graded in the air-dry condition and, if they dropped in grade, the reason for the degrade was recorded. The pile and benchmark samples were treated in the same manner except that they were not graded.

Most of the lumber from the piles of 4/4 common was planed after it was air dried. The lumber was graded after being planed and where there was a drop in grade the reason was given.

Observed Data

Climatological: Flagstaff is at an elevation of appoximately 6,900 feet; Snowflake about 80 miles away, is about 2,000 feet lower. As a consequence Snowflake is warmer and drier than Flagstaff. Temperatures at Snowflake average 7° F. above that at Flagstaff. Relative humidity at Snowflake averages almost 6 per cent lower than at Flagstaff. Total annual rainfall at Snowflake is 6 inches less than at Flagstaff. Climatological conditions affect air-drying rates, minimum moisture content values that can be attained, and development of drying defects.

Figs. 5 and 6 show the climatological data for Snowflake and Flagstaff respectively, as obtained from U. S. Weather Bureau reports. The wood equilibrium moisture content curve is based on the monthly mean temperatures and relative humidities.

The high temperatures during July and August are accompanied by moderately high relative humidity. During the time of the study, relative humidity at Snowflake was comparatively low during April, May, June, and September; the relative humidity during February was moderate. At Flagstaff, January and July are the months of high relative humidity with August, March, and December next. June is the month of lowest relative humidity, with September and May next in order. At both places, the heaviest rainfall occurs during July and August.

With relative humidity, temperature, and rainfall as criteria, the year can be divided into periods of different air-drying intensity. At Snowflake the months of April, May, and June constitute a period of rapid drying. The month of September is a secondary period of rapid drying. The months of July and August are a period of slow drying because of high relative humidity and heavy rainfall. The late fall and winter months are

characterized by generally high relative humidities and low temperatures, both of which result in slow drying. The conditions at Flagstaff are similar except that the spring period of rapid drying does not include April.

Drying Periods

Table 1 gives moisture content values lumber can be expected to attain in various months, as calculated for Flagstaff and Snowflake on the basis of mean monthly temperature and relative humidity. Lumber piled at Flagstaff can reach a moisture content of 10 per cent during February, April, May, June, August September, October, and November. Lumber piled at Snowflake can reach a moisture content of 10 per cent during all months except January, July, and December.

One-inch lumber: Piles of 1-inch No. 3 common and better were erected at Snowflake during June and October 1953 and January 1954 and at Flagstaff during July and October 1953 and January and May 1954. Since the climate of Snowflake averages both warmer and drier than that of Flagstaff, the drying periods were correspondingly shorter at Snowflake. Table 2 gives the periods required to air dry 4/4 boards to moisture content values of 10 and 15 per cent at Snowflake. The periods needed to reach 10 per cent moisture content range from 10 to 150 days.

The values in Table 2 were obtained by the use of actual and calculated[5] drying curves for the three test piles of 4/4 lumber at Snowflake and extrapolation based on climatological data. For example, the June pile never actually reached a moisture content of 10 per cent because of rains near the end of the drying period. The drying rate over the first 6 days, however, indicated that the lumber would have reached 10 per cent moisture content in 8–½ to 10 days if there had been no rain. A minimum period of 10 days was established, therefore, for air drying 4/4 common at Snowflake.

[5] The method used for calculating drying curves and periods is described in the appendix.

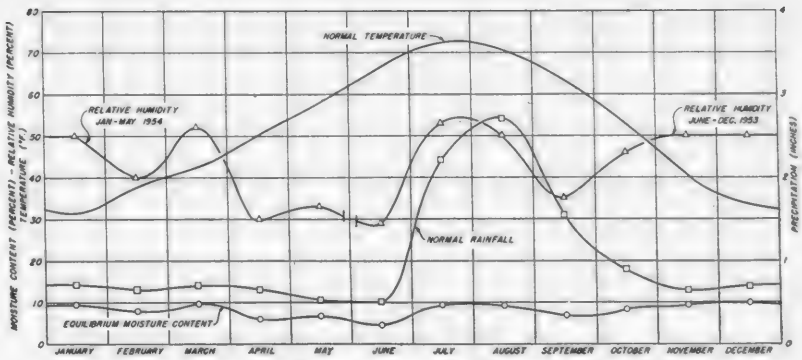
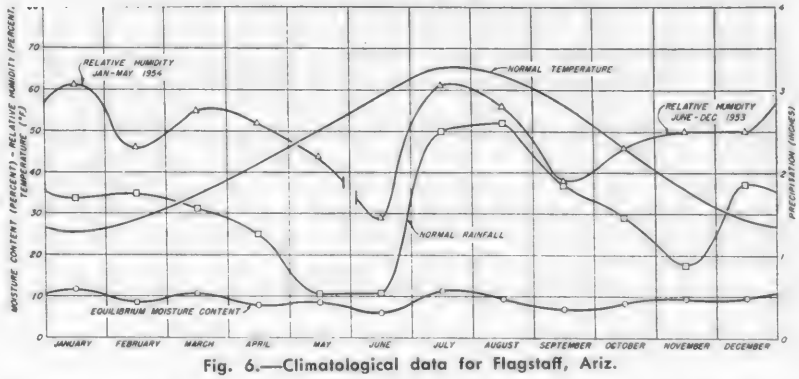

NORMAL TEMPERATURE
RELATIVE HUMIDITY JAN-MAY 1954
RELATIVE HUMIDITY JUNE-DEC. 1953
NORMAL RAINFALL
EQUILIBRIUM MOISTURE CONTENT
MOISTURE CONTENT (PERCENT) - RELATIVE HUMIDITY (PERCENT) TEMPERATURE (°F.)
PRECIPITATION (INCHES)
JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER

Fig. 5.—Climatological data for Snowflake, Ariz.


RELATIVE HUMIDITY JAN-MAY 1954
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RELATIVE HUMIDITY JUNE-DEC 1953
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EQUILIBRIUM MOISTURE CONTENT
MOISTURE CONTENT (PERCENT) - RELATIVE HUMIDITY (PERCENT) TEMPERATURE (°F.)
PRECIPITATION (INCHES)
JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER

Fig. 6.—Climatological data for Flagstaff, Ariz.

The October pile was taken down in November, at which time the moisture content of the lumber was 13.6 per cent. The relative humidity during December and January corresponds to a wood equilibrium moisture content of about 10 per cent. Adding 1 per cent to this value gives 11 per cent. Consequently, the lumber in the October pile could not have reached a moisture content of 10 per cent during December or January. A moisture content of 10 per cent would probably have been reached during February or March. The maximum air-drying period of 120 to 150 days was selected on this basis.

The lumber of the January pile reached a moisture content of 8 per cent during February, or after 46 days;

Table 1.—MINIMUM MOISTURE CONTENT ATTAINABLE IN PONDEROSA PINE EXPOSED OUTDOORS DURING EACH MONTH OF THE YEAR

Month	Moisture content	
	Flagstaff* Per cent	Snowflake* Per cent
January	13	11
February	10	9
March	12	10
April	9	7
May	9	8
June	7	6
July	12	11
August	10	10
September	8	8
October	9	9
November	10	10
December	11	11

*These values were obtained by adding 1 per cent to the equilibrium moisture content values for wood corresponding to the monthly mean temperature and relative humidity.

Table 2.—PERIODS NEEDED TO AIR DRY PONDEROSA PINE TO MOISTURE CONTENT VALUES OF 10 AND 15 PER CENT AT SNOWFLAKE AND FLAGSTAFF, ARIZ.

Month of pile erection	Drying period							
	4/4 Common				6/4 Shop at Flagstaff		8/4 Common at Snowflake	
	Snowflake		Flagstaff					
	15 per cent moisture content Days	10 per cent moisture content Days	15 per cent moisture content Days	10 per cent moisture content Days	15 per cent moisture content Days	10 per cent moisture content Days	15 per cent moisture content Days	10 per cent moisture content Days
January	22	40	51	89	85	130	69	110
February	16	30	34	60	67	100	50	80
March	19	30	17	30	64	90	38	60
April	10	15	10	18	43	60	19	30
May	6	10	10	18	25	36	10	15
June	7	10	7	12	25	36	10	15
July	32	60	41	75	52	75	55	90
August	26	45	34	60	40	60	34	60
September	9	15	9	15	130	200	17	30
October	83	150*	94	170†	110	170	104	170
November	59	120*	79	140†	97	150	87	140
December	44	90*	62	110	95	140	75	120

*These values possibly can be reduced by 20 to 30 days.
†There is a possibility that these values can be reduced by 30 to 60 days.

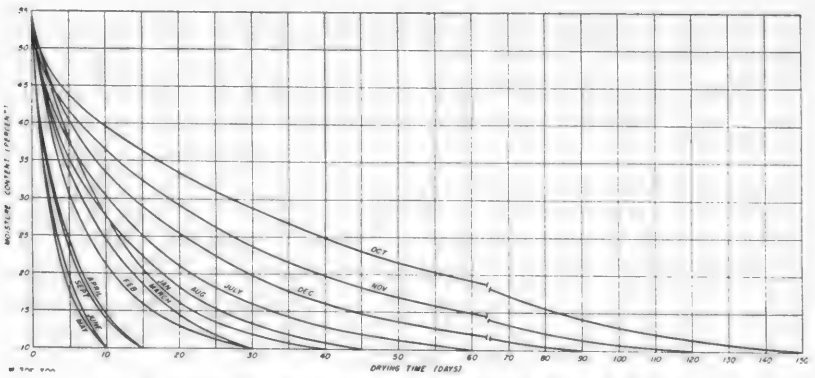

Fig. 7.—Calculated drying curves for 4/4 lumber piled at Snowflake.

it reached 10 per cent in 40 days. The air-drying periods for lumber piled during the other months were estimated and drying curves were calculated as described in the Appendix (Fig. 7).[6]

The periods given in Table 2 to air-dry lumber to a moisture content of 15 per cent were picked from calculated drying curves. Where the test piles reached a moisture content of 15 per cent in a relatively short period, but did not reach a moisture content of 10 per cent during a considerably longer period, the calculated periods for the 15 per cent moisture content figure are subject to large errors.

The periods required to air dry 4/4 No. 3 common and better at Flagstaff to a moisture content of 10 per cent range from 12 to 170 days. (Table 2). These data show that 4/4 lumber piled in October will not reach 10 per cent moisture content until the following April, 170 days later. There is, however, a possibility that 4/4 lumber piled early in October might reach 10 per cent moisture content in November or in February. The drying periods for lumber piled during the months of October to March inclusive were calculated on the basis of the attainment of 10 per cent moisture content in April.

Calculated drying curves were drawn for 4/4 No. 3 common and better piled at Flagstaff.

Shop lumber: The air drying of 6/4 shop lumber differed considerably from the air drying of 4/4 common. The higher green moisture content of the sapwood together with the added thickness, caused the drying periods to be longer. The data indicate that shop lumber can be air dried to 10 per cent in 36 to 200 days. (Table 2). The 36-day period applies to shop lumber piled during May and June and dried before the July showers come. The relatively dry month of September is not long enough to reduce the moisture content to 10 per cent. Lumber piled during July and August reaches 10 per cent during September. Occasionally 6/4 shop piled in September might reach 10 per cent in October or November if weather conditions were particularly favorable to drying.

Two-inch lumber: It took from 15 to 170 days to air dry 8/4 lumber to a moisture content of 10 per cent at Snowflake. Data indicate that lumber piled during May and the first half of June will reach 10 per cent in 15 days (Table 2). Lumber piled in April and September requires 30 days. Lumber piled in July and August reaches a moisture content of 10 per cent during September. Lumber piled during October does not each 10 per cent until the following April.

The effect of rain on drying periods varies. Rain falling near the start of a drying period has less effect than one falling near the end. Rain has more effect on a short period than on a long one. For example, a rainstorm occurring on the day a pile is erected has no measurable effect if the drying period is a long one, but a 10-day drying period may be lengthened by a day. Rain during the last day of a drying period when the lumber is near or at 10 per cent moisture content will prolong the period several days.

Surface Checking

Lumber that surface checks severely during air drying is seriously downgraded. For this reason, checking was critically observed. Total length of surface checks was measured in inches on both faces of a 16-foot board. Total checking in the 3–½–foot pile and benchmark samples was adjusted to a 16-foot board length.

Table 3 gives the amount of surface checking for the benchmark, pile, and whole-board samples of all test piles. The benchmark samples generally surface checked more than the pile or whole-board samples, presumably because they were completely exposed. The 8/4 No. 3 common and better lumber surface checked more than the 4/4 No. 3 common and better or the 6/4 shop. The 4/4 lumber surface checked least.

One-inch lumber: The surface checking of the whole-board samples indicates that 4/4 lumber piled during May or June tends to surface check more than that piled in October or January. These data are not entirely consistent but they indicate that 4/4 lumber checks most under severe drying conditions. The 4/4 lumber piled at Snowflake surface checked somewhat more than that piled at Flagstaff.

Shop lumber: Using the surface checking of the whole-board samples as a basis, the 6/4 shop lumber piled during May checked most. During May the weather was hot and dry. The lumber piled in January surface checked more than that piled in July

[6] Similar calculated curves were drawn for the 4/4 and 6/4 lumber piled at Flagstaff, and the 8/4 lumber piled at Snowflake.

Table 3.—SURFACE CHECKING OF AIR-DRIED PONDEROSA PINE AT SNOWFLAKE AND FLAGSTAFF, ARIZ.

Location	Lumber thickness and grade	Type of sample	Total surface checking during air drying			
			June–July 1953 Inches	October 1953 Inches	January 1954 Inches	May 1954 Inches
Snowflake	4/4, No. 3 Common and Better	Benchmark	65	48	48	---
	4/4, No. 3 Common and Better	Pile	16	12	13	---
	4/4, No. 3 Common and Better	Whole-board	19	2	8	---
Flagstaff	4/4, No. 3 Common and Better	Benchmark	24	92	26	133
	4/4, No. 3 Common and Better	Pile	6	46	0	141
	4/4, No. 3 Common and Better	Whole-board	4	9	7	15
Snowflake	8/4, No. 3 Common and Better (2-inch stickers)	Benchmark	202	81	158	---
	8/4, No. 3 Common and Better (2-inch stickers)	Pile	207	73	141	---
	8/4, No. 3 Common and Better (2-inch stickers)	Whole-board	145	83	113	---
Snowflake	8/4, No. 3 Common and Better (25/32-inch stickers)	Pile	168	121	117	---
	8/4, No. 5 Common and Better (25/32-inch stickers)	Whole-board	180	73	88	---
Flagstaff	6/4 Shop	Benchmark	219	101	153	260
	6/4 Shop	Pile	57	53	139	159
	6/4 Shop	Whole-board	7	55	140	176

and October, probably because the temperature during January averaged below freezing and consequently the large amount of water in the shop lumber was frozen. The small amount of surface checking in the July pile may have been due to the showers and mild drying conditions that came shortly after the pile was erected.

Two-inch lumber: The whole-board samples of the June piles surface checked considerably more than those of the other piles. The lumber in the June piles dried to a moisture of 18 per cent, and had surface checked severely before the July showers came. In the October and January piles, the lumber dried under milder conditions, particularly during the early part of the air-drying period. The 8/4 common lumber contained less water than the 6/4 shop and consequently did not surface check because of freezing.

One group of piles of 8/4 lumber was made with 25/32-inch and the other with 2-inch stickers. The average amount of surface checking in the three piles of each group was the same. The thinner stickers were used to permit the piling of more lumber in a unit package of given size and to retard drying by reducing air circulation. Some temporary retarding effect was evident, but apparently not enough to reduce surface checking.

Degrade During Air Drying

Drying defects, such as surface checking, end splitting, warping, staining, and the checking and loosening of knots, affect the grade of lumber adversely. Drying defects hence may cause dollar losses and sometimes material losses. For example, board may drop to No. 5 common, for which there is no market; or an end trim may be required.

Table 4 gives the dollar losses due to drying degrade, per thousand board-feet, and in percentage of green value for the lumber of all test piles. Prices on which calculated value losses are based are given in the Appendix. The losses in per cent of the green value are the best figures for comparisons among the different piles.

The losses during air drying increase with the thickness of the lumber. Piles made in January 1954 sustained the heaviest losses. The losses for the 4/4 lumber air dried at Snowflake were greater than those for the 4/4 lumber air dried at Flagstaff.

The losses in value for the piles of 8/4 lumber piler with 25/32-inch stickers were slightly less than those for the piles with 2-inch stickers.

Surface checking was the chief air-drying defect. Loose and checked knots, warp, and shake also contributed to degrade and loss in value. Considering all the piles, the correlation between the surface checking of the 36 whole-board samples (Table 3) and losses in value is not close. The total length of the surface checks is not a direct measure of their effect on degrade. A few wide and deep surface checks are more likely to cause a drop in grade than many narrow and shallow ones.

To get data on common lumber only, the data for losses due to air-drying defects were analyzed after eliminating the comparatively few boards that were of considerably higher green grade than the general grade level of the pile. This analysis was limited to Nos. 2, 3, and 4 common in the 4/4 and 8/4 lumber and Nos. 1, 2, and 3 shop in the shop lumber. In addition, the boards in the top two courses of the pile were eliminated. Table 5 gives the resulting figures.

The losses per thousand board-feet and in per cent of green value are less in Table 5 than those in Table 4 except in three instances. However, the conclusions reached are generally unchanged.

The boards in the two top courses of the unroofed piles developed more severe drying defects than those lower down in the piles. Table 6 gives net losses in value and net losses in terms of percentage of the green value for the boards in the two upper courses. The general average losses per pile were: 4/4, $1.15; 6/4, $3.94; and 8/4, $5.39. The general average losses in percentage were 4/4, 10.2; 6/4, 16.6; and 8/4, 19.2.

The losses were heaviest in the January piles except for the 4/4 piles at Flagstaff. The May pile showed the heaviest loss for the piles of 6/4 shop. For all piles, the average loss of the

Table 4.—LOSS IN VALUE OF PONDEROSA PINE DURING AIR DRYING AT SNOWFLAKE AND FLAGSTAFF, ARIZ.

Location	Lumber thickness and grade	Loss: Per thousand board feet: June–July 1953 Dollars	October 1953 Dollars	January 1954 Dollars	May 1954 Dollars	Loss: Per cent of green value: June–July 1953	October 1953	January 1954	May 1954	Major cause of degrade and loss
Snowflake	4/4, No. 3 Common and Better	2.03	1.77	7.23	-----	2.4	1.7	7.5	----	Surface checks, June–July and January; loose knots, October
Flagstff	4/4, No. 3 Common and Better	1.86	1.21	3.14	2.50	2.3	1.4	3.4	3.0	Surface checks, June–July and October; cross checks, checked knots and warp, January; shake and loose knots, May
Flagstaff	6/4 Shop	5.29	7.77	26.09	16.37	4.0	6.3	16.6	12.2	Surface checks, October and January; surface checks and warp, June–July and May
Snowflake	8/4, No. 3 Common and Better (2-inch stickers)	15.36	5.66	16.73	-----	16.2	6.1	17.6	----	Surface checks all piles
Snowflake	8/4, No. 3 Common and Better (25/32-inch stickers)	11.86	7.52	13.06	-----	13.1	8.2	14.5	----	Surface checks all piles

Table 5.—LOSS OF GRADE AND VALUE DURING AIR DRYING OF PONDEROSA PINE AT SNOWFLAKE AND FLAGSTAFF, ARIZ., IN PILES ERECTED DURING JUNE–JULY AND OCTOBER 1953 AND JANUARY AND MAY 1954, INCLUDING ONLY NOS. 2, 3, AND 4 COMMON IN 4/4 AND 8/4, AND NOS. 1, 2, AND 3 SHOP, AND ELIMINATING THE TWO UPPER LUMBER COURSES OF EACH PILE.

Location	Lumber thickness and grade	Loss per pile: Total: June–July 1953 Dollars	October 1953 Dollars	January 1954 Dollars	May 1954 Dollars	Per thousand board measure: June–July 1953 Dollars	October 1953 Dollars	January 1954 Dollars	May 1954 Dollars	Per cent of green value: June–July 1953	October 1953	January 1954	May 1954
Snowflake	4/4, No. 3 Common and Better	4.85	5.47	13.78	-----	1.46	1.96	4.39	-----	1.7	2.2	4.9	
Flagstaff	4/4, No. 3 Common and Better	5.98	4.20	13.82	10.43	1.38	1.04	3.38	2.46	1.7	1.3	3.8	3.0
Flagstaff	6/4 Shop	11.15	31.04	22.82	27.89	3.70	8.92	12.81	8.99	3.4	8.2	10.8	7.8
Snowflake	8/4, No. 3 Common and Better (2-inch stickers)	70.44	17.88	64.74	-----	14.64	3.88	13.47	-----	15.5	4.4	14.7	
Snowflake	8/4, No. 3 Common and Better (25/32-inch stickers)	52.38	26.25	49.00	-----	11.14	5.37	10.26	-----	12.4	6.1	11.5	

Table 6.—LOSS IN VALUE OF BOARDS IN THE TWO UPPER COURSES OF THE PILES FROM EXPOSURE TO SUNSHINE AND WETTING DURING AIR DRYING OF PONDEROSA PINE AT SNOWFLAKE AND FLAGSTAFF, ARIZ., IN PILES ERECTED DURING JUNE–JULY AND OCTOBER 1953 AND JANUARY AND MAY 1954

Location	Lumber thickness and grade	Loss							
		Value				Per cent of green value			
		June–July 1953 Dollars	October 1953 Dollars	January 1954 Dollars	May 1954 Dollars	June–July 1953	October 1953	January 1954	May 1954
Snowflake	4/4, No. 3 Common and Better	1.78	0*	2.83	----	16.0	0*	23.9	---
Flagstaff	4/4, No. 3 Common and Better	2.05	.82	.28	0.32	19.0	6.9	2.7	3.0
Flagstaff	6/4 Shop	2.48	1.54	5.71	6.04	13.9	9.1	19.0	24.4
Snowflake	8/4, No. 3 Common and Better (2-inch stickers)	.25	3.11	4.27	----	1.1	10.5	16.8	---
Snowflake	8/4, No. 3 Common and Better (25/32-inch stickers)	2.89	8.56	13.06	----	12.6	25.4	48.7	---

*These values are less than those for the bulk of the pile.

Table 7.—LOSS IN VALUE DURING THE PLANING OF 4/4 LUMBER AIR DRIED AT SNOWFLAKE AND FLAGSTAFF, ARIZ., IN PILES ERECTED DURING JUNE–JULY AND OCTOBER 1953 AND JANUARY AND MAY 1954

Location	Loss								Moisture content when planed			
	Value per thousand board measure				Per cent of green value							
	June–July 1953 Dollars	October 1953 Dollars	January 1954 Dollars	May 1954 Dollars	June–July 1953	October 1953	January 1954	May 1954	June–July 1953 Per cent	October 1953 Per cent	January 1954 Per cent	May 1954 Per cent
Snowflake	1.92 (2.03)*	3.12 (1.77)	---- ----	---- ----	2.2 (2.4)	3.0 (1.7)	---- ----	---- ----	11.5	13.5	----	----
Flagstaff	1.25 (1.86)	.80 (1.21)	9.64 (3.14)	4.29 (2.50)	1.5 (2.3)	1.0 (1.4)	10.6 (3.4)	5.2 (3.0)	13.0	15.0†	10.1	10.4

*Values in parentheses are losses that occurred during air drying.
†This lumber was wetted by rain and snow when the pile was taken down.

top course was $2.81 while that of the next course was $0.74. The difference was due to the greater surface checking of the boards in the top course.

Degrade During Planing

Table 7 gives the losses that occurred during planing in values per thousand board-feet, and in percentage of green value, together with the average moisture content of the lumber at the time of planing. It also gives the losses that occurred during air drying from green to rough-dry condition. If all piles are considered, the average degrade is greater during planing than during air drying. Of the 6 piles, however, 3 degraded more during planing and 3 degraded more during air drying.

The heavy planing degrade in the January and May piles at Flagstaff caused the average loss to be greater during planing than during air drying. The planing losses at Snowflake were greater than those at Flagstaff. However, the lumber of the June–July and October piles at Snowflake was planed at a lower moisture content than that at Flagstaff.

That moisture content plays an important part in loss during planing is evidenced by the data for the four piles at Flagstaff. Planing 4/4 common lumber at a moisture content of about 10 per cent results in heavy degrade, approximately $10 per thousand board-feet. The October pile of 4/4 lumber that was wetted by snow and rain at the time it was taken down was planed with a loss of only $0.80 per thousand board-feet. The average moisture content of this lumber was 15 per cent. After planing, the average was presumably lower because much of the surface moisture was removed.

Summary

1. Four-quarter common boards, piled in Arizona, can be air dried to 15 per cent moisture content in 6 to 94 days or to 10 per cent moisture content in 10 to 170 days.

2. Eight-quarter common boards, piled in Arizona, can be air dried to 15 per cent moisture content in 10 to 104 days or to 10 per cent moisture content in 15 to 170 days.

3. Six-quarter shop, piled in Arizona, can be air dried to 15 per cent moisture content in 25 to 130 days or to 10 per cent moisture content in 36 to 200 days.

4. Air drying defects, principally surface checks, cause degrade and loss in value. The average loss per thousand board-feet was $2.82 for 4/4, $11.70 for 8/4, and $13.80 for 6/4 shop grades.

5. The loss per pile resulting from the lack of a pile roof was $1.15 for 4/4, $5.36 for 8/4, and $3.94 for 6/4 shop.

6. The average loss per thousand boardfeet due to planing of 4/4 boards was $3.50.

7. 4/4 boards planed at about 10 per cent moisture content dropped in value $9.64 per thousand board-feet, compared to $0.80 for lumber planed at 15 per cent moisture content.

Appendix

Because it was impossible to maintain an individual at the sites of the experiments to collect current data during the entire air-drying periods, pertinent data were often lacking. Adequate data were obtained during the first week to 10 days of each experiment, but for the rest of the period the data were obtained at irregular intervals. When the test piles were dismantled, the final moisture content was usually higher or lower than the goal of 10 per cent. Since the object was to determine drying periods necessary to attain a moisture content of 10 per cent, interpolation and extrapolation were necessary.

There were only two instances where the lumber actually reached a moisture content of 10 per cent according to the moisture content determinations on the pile and wholeboard samples. In some instances there was reason to surmise that the samples may have reached a moisture content of 10 per cent prior to the time that the pile was dismantled. The lumber of all piles exeept two actually reached a moisture content of 15 per cent.

Following is a description of the method used for calculating drying curves and thereby determining drying periods.

Calculated Drying Curves: Sherwood[7] developed a theory applicable to the drying of water from porous

[7] Sherwood, T. K. 1929. Ind. Eng. Chem. 21. 12.

solids by evaporation in air. Newman[8] developed equations and tables giving the relation between the amount of evaporable moisture, *E*, and a function of time. The function of time is expressed by $T = \frac{k\Theta}{a^2}$ where *k* is the diffusivity constant, Θ is time, and *a* is the distance through which the moisture must travel to the surface.

Newman's tables were applied to the drying of wood, and a chart (Fig. 8) was constructed with the vertical axis so adjusted that a drying curve of a piece of wood would plot a straight line. The heavy diagonal line drawn on the chart has coordinated equal to the values in the E—T table.

It is well known that a drying piece of wood follows this law only approximately. If the initial green moisture content and the time required to reach a certain moisture content are known, the entire drying curve for a piece of wood, or for the average of a number of pieces, can be plotted. An obviously eroneous assumption must be made, however, that temperature and relative humidity are constant throughout the drying period. Because they vary, the best that actually can be done is to use monthly mean values and the coresponding wood equilibrium moisture content values. For long air-drying periods, the equilibrium moisture content was selected that agreed with the mean temperature and relative humidity of the last 2 months of each period.

The following example illustrates the application of the method. A pile of 4/4 No. 3 common and better lumber was erected at Snowflake June 26 and taken down July 6, 1953. On the sixth day the samples averaged 13.6 per cent. On the ninth and tenth days 0.28 inch of rain fell. When the pile was taken down the 16 pile samples averaged 11.1 per cent moisture content. Since the month of June at Snowflake is generally the month of lowest mean relative humidity and moderately hot, it was hoped to obtain the shortest drying period for the 4/4 lumber from this test pile. The question is, therefore, how long would the drying period have been that was required to bring the moisture content to 10 per cent if rain had not fallen on the last 2 days?

Initial average moisture content of 16 samples	60.1 per cent
Assumed equilibrium moisture content	7.0 per cent
Total evaporable moisture	53.1 per cent
Moisture content after 6 days of drying	13.6 per cent
Loss in moisture content in 6 days	60.1 − 13.6 = 46.5 per cent
Evaporable moisture after 6 days of drying	$1 - \frac{46.5}{53.1} = 0.124$

[8] Newman, Albert B. 1932. Cooper Union Bulletin. The drying of porous solids: diffusion calculations, diffusion, and surface emission equations.

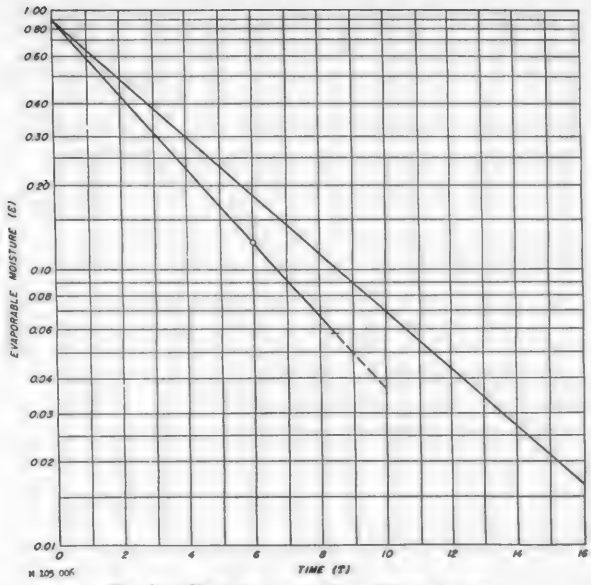

Fig. 8.—Chart for calculating drying curves.

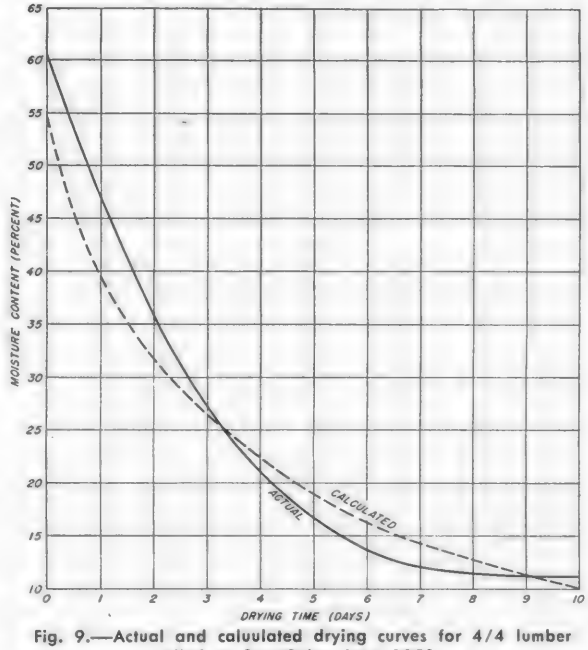

Fig. 9.—Actual and calculated drying curves for 4/4 lumber piled at Snowflake, June 1953.

The value of E is 0.124 after 6 days. The value of E at 10 per cent moisture content is:

$$1 - \frac{60.1 - 10.0}{53.1} = 0.057$$

When 0.124 E is plotted against 6 T in Fig. 8 and a straight line is drawn through the origin, an intersection of 0.057 E occurs at about 8.5 T. On this basis the time required to reach a moisture content of 10 per cent becomes 8–½ days. The drying time was therefore conservatively estimated to be 10 days.

A calculated drying curve can be drawn by working with the E and T values of the straight line and applying them to the green moisture content and to the assumed equilibrium moisture content. For example the calculated moisture content after 4 days of drying, with E equal to 0.23, is approximately: moisture content = 0.23 (53.1) + 7.0 = 19.2 per cent.

The calculated drying curve shown in Fig. 9 was not derived from this straight line; it was drawn on the basis of the average green moisture content of all of the samples of 4/4 lumber at Snowflake, rather than the average green moisture content of the 16 samples of the June pile, and an equilibrium moisture content of 5.0 per cent. In addition, this second curve was drawn on the basis of the attainment of 10 per cent moisture content in 10 days instead of 8–½.

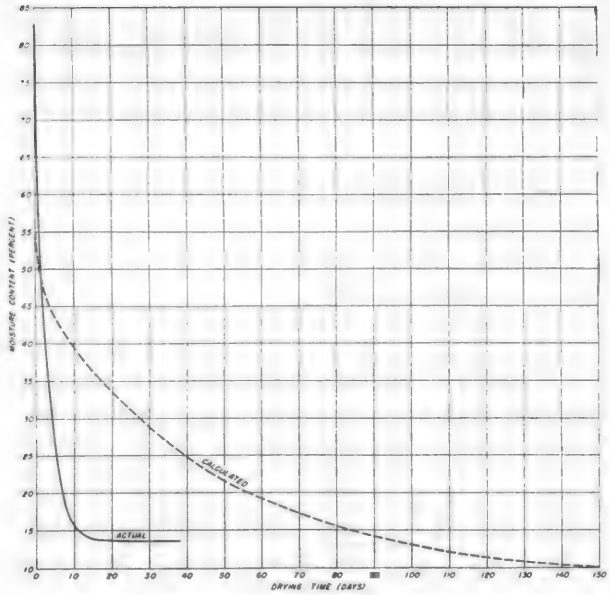

Fig. 10.—Actual and calculated drying curves for 4/4 lumber piled at Snowflake, October 1953.

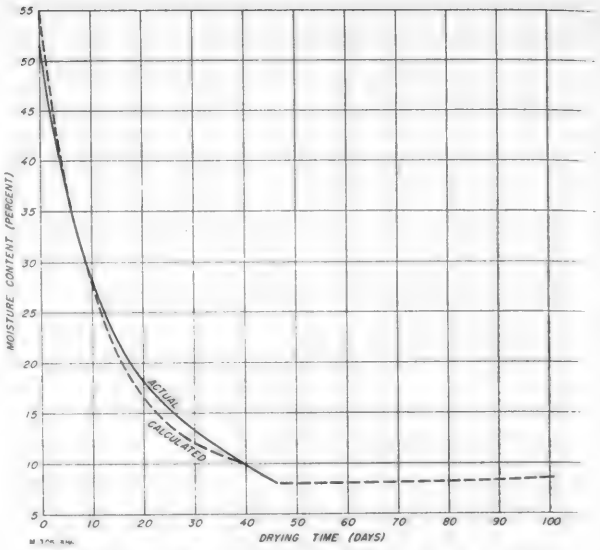

Fig. 11.—Actual and calculated drying curves for 4/4 lumber piled at Snowflake, January 1954.

Figs. 10 and 11 show how the actual and the calculated drying curves compare. Where the weather was nearly constant during the drying period, the actual and calculated drying curves nearly coincide. This is illustrated by the pairs of curves in Figs. 9 and 11. Where the weather underwent drastic changes during the drying period, the curves are separated widely (Fig. 12).

This pile was dismantled during November after 38 days of drying. When the pile was taken down, the average moisture content was 13.6 per cent. If these values are used, 13.6 per cent moisture content in 38 days, then the calculated time to reach 10 per cent would be considerably shorter than the 150 days shown. The relative humidity was too high during November, December, and January, however, to permit the lumber to reach 10 per cent moisture content. Consequently, it was assumed that the lumber reached a moisture content of 10 per cent in March, or in 150 days. Using these values, the calculated drying curve was derived.

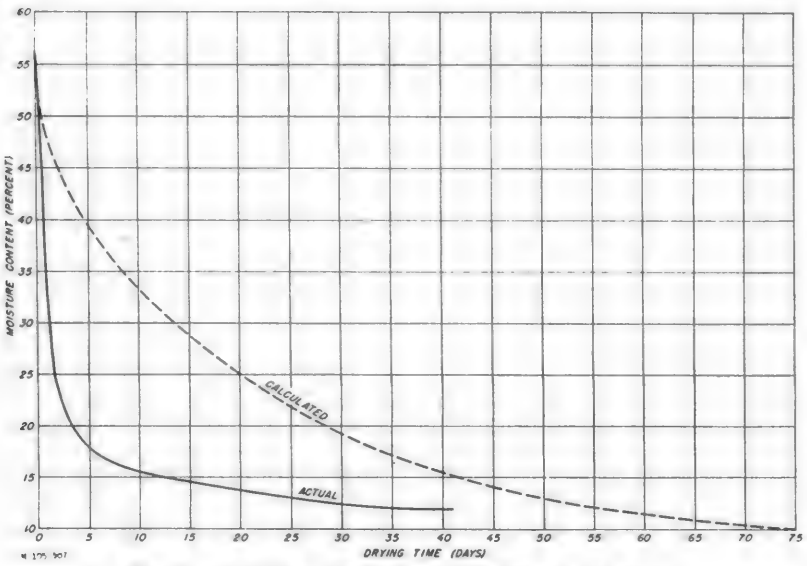

Fig. 12.—Actual and calculated drying curves for 4/4 lumber piled at Flagstaff, July 1953.

Lumber Prices Used

The following lumber prices were taken from American Lumberman, July 1953. The prices of grades that were not listed are estimated by the authors.

Grade	Price per M.B.M
C and better	$255
D	205
3 Clear	190
1 Shop	142
2 Shop	110
3 Shop	90
Molding	150
2 Common and Better	128
3 Common	84
4 Common	64
Box	75
4 Common 6/4	75
5 Common	6

The Roots of Research[1]

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Research is deeply rooted in the hazards of living and the problems of thinking. Paradoxes and contradictions, objects already in Greek philosophy, are inciting scientific studies. The method of first isolating significant factors, then combining these factors to represent the complicated realities, has its roots in free play and disciplined imagination. To nourish the roots of research, we should direct education toward developing skill and imagination in play, thoroughness and understanding with the help of the history of science.

Source and Objective

THE GREAT EXPANSION OF RESEARCH in recent years has brought with it much thinking about the problems and mechanics of this activity. In the flood of publications on research, the commercial results are pointed out with pride, but the difficulties of stimulating pure research are viewed with alarm. Many attempts at defining the realms of research have remained ambiguous, and there has been much debate on stating in a few words what distinguishes the pure from the applied.

Disappointments and frustrations with particular problems have led to an emphasis on the objectives of a specific undertaking in research. This was, and remains, salutary. However, the emphasis can go too far. It can blur the view of the sources by concentrating all attention on the goals, and it does not answer the basic questions. Does research never end? Is the field of the unknown so great? Can we expect to find new ways to chart the unknown? What keeps us going?

In some respects these questions must be taken seriously. It is not enough to point back to the old Commissioner of Patents who declared about 120 years ago, so many inventions had already been made that new ones were impossible. We find similar thinking today in men of importance and influence.

Scientists may be to blame for that. Perhaps we have concerned ourselves too much with objectives of research and with paradoxes of theory. For practical reasons we need to go back to the fundamentals. This is fortunate, because the basis of research should be constantly restated for both theory and practice. Basic theory is still the best way to good practice, or as Goethe expressed it:

"To take hold of truest value
One must live from the foundations" (1)[2]

Under this aspect, it appears strange that while in our theoretical climate we exclude final causes and purposive forces, nevertheless in practice we direct our research by objectives. Such a discrepancy makes it the more important to return to the sources, to the roots of research.

Symbols and Analogies

To describe what we mean, we have to use symbols and analogies. The word root is here used to connect, by a symbol, scientific growth with a plant, say a tree, indicating that from which the growth obtains a firm hold and continuous nourishment. A symbol is not meant to be an accurate or complete picture of reality. We may extend it into an analogy and explore its helpful range. The tree derives nourishment also from the air. It is not intended; in the present study, to consider symbolic leaves of research.

The analogy to organic growth, however, is part of this study, because science and research are expressions of our lives. Growth is essential to science because it is a function of life. It is the "irresistible force" of which Max Planck said, "that the continual displacement of one world picture by another . . . is dictated . . . by an irresistible force" (2).

In life, growth consists in building new cells. In science, we develop new "molecules" out of the atoms of experience; then we make "laws" to correlate and cover the scientific molecules (3). The process recurs in art. Tennessee Williams once described it as follows: ". . . I began to find life unsatisfactory as an explanation of itself and was forced to adopt the method of the artist of not explaining but putting the blocks together in some other way that seems more significant to him" (4). Fundamentally, the "blocks" of the artist are like the "molecules" of the scientist.

The roots of research are spread out widely in the fertile soils of thinking and feeling, of philosophy and legend. To follow these roots there may help us to understand the tree that grows from them and of which they are an essential part.

Flow and Permanence

Before considering the urgency in thoughts and feelings from which research was, and is, nourished, I have to guard against the accusation that the material necessities are being neglected. History contains strong indications that the satisfaction of material needs had much less to do with incipient research than the sense of form and the experience of joy or fear. I know that this broad statement should be substantiated by a deeper discussion; for our present context it is more significant that, in general, as soon as one aspect of historical reality is brought out, an opposite aspect can be held against it.

That is an old situation. One of its first great models, dating from about 500 B. C., is the contradiction between the philosophies of Heraclitus and Parmenides. Heraclitus of Ephesos was the poetic seer to whom everything was constantly changing, while Parmenides of Elea pronounced as his conviction that nothing can change. Both felt they had experienced from the roots of existence. Yet for one of them, fire and the ever flowing water in the river were great symbols; for

[1] A contributed paper.

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[2] Numbers in parentheses refer to literature cited.

the other, change would, logically, imply that one state of being would cease and thus become not being which contradicts our experience "because you can neither recognize nor express the not being" (5).

Together with their unifying principles, both philosophers recognized the existence of contradictions. They formalized them into pairs of contraries. Heraclitus stated them as day/night, winter/summer, war/peace, satisfaction/hunger. Parmenides reduced them to qualities and their elemental representations: warm and bright is the ethereal fire, dark and cold is air, and so is its condensation, earth.

The contradictions between continuous flow and permanent being are disturbing enough, yet they are only the most general ones. We recognize many, more specific, contraries. Pythagoras of Samos, who died 497 B. C., tabulated ten such pairs. Whatever it is that makes these contradictions necessary, our being aware of them is itself both changing and permanent. The essential need for research has its roots here, and they develop from here in many directions. They become, psychologically: drives and purposes; philosophically: the problems of converting the opposite concepts from contradiction to complimentarily and identity; scientifically: the measurement of flow by erecting guideposts, and the definition of permanence on a sliding scale; economically: the satisfaction of existing needs and the creation of new ones.

Out of these roots grew the dualistic theories in chemistry, or the concept of polarity in electricity. Polarity can also be seen in the conversion of a negative into a positive type of explanation. From a feeling for a horror vacui we changed to the recognition of the positive pressure of air. In his doctor's thesis on tertian fever, Isaac Beeckman (1588–1637, Dordrecht) wrote about barometric experiments: "The water under suction is not attracted by a vacuum, it is impelled into the place of vacuum by the surrounding air" (6).

The development of science is characterized by many such changes from one position to its opposite. They have often brought decisive progress. The revolution in astronomy connected with the name Coppernicus is a generally important example for such events in science. However, they can be viewed from an opposite standpoint. Since we had to change our fundamental position so frequently, we ought to conclude that all our fundamental concepts are uncertain. This thought has often been expressed. Charles Sanders Pierce (1839–1914) emphasized: "no concept, not even those of mathematics, is absolutely precise" (7).

Emile Boutroux argued that the principle of causality is vague, "it can nowhere in the concrete and real world be strictly applied" (8). To a modern scientist like J. W. N. Sullivan, it seems "highly probable"—even this is not *certain*—"that all scientific theories are wrong." Science is an adventure, it is now more mysterious than ever (9). Norbert Wiener is somewhat more conciliatory: "We mathematicians are in the habit of testing a sharp hyphothesis by considering it in its extreme case. If it then fails it may not be altogether useless, but at least it needs modification and restriction" (10).

In a speech of April 30, 1953, Thomas H. Johnson, AEC, stated: "The more specifically one tries to define the practical purpose of research, the more indefinite becomes its bearing on the important questions of science and the less reason a scientist can find for doing it". The scientific principle of indeterminacy is here exemplified in its application to the systems of pure science and practical purpose.

Despair and Self-Help

Through Heisenberg's theory we have discovered a rule for indeterminacy; we can therefore appreciate that vagueness in our concepts is necessary. We have to keep within limits; if we do, then we can live in fruitful, not despairing, resignation. For some of us, this is very unsatisfactory; science seems to lose all value if research has limits and if the great concepts of which man is capable have to remain outside of our exact understanding. Doctor Faustus is the legendary symbol of our despair in absolute knowledge. For decades, Goethe, the scientist and poet, was haunted by this symbol. As he finally reshaped it, Faust is the man who recognized that all his valiant study left him "no wiser than before".

Man cannot learn, cannot go beyond what he brings to this world at birth. At least we cannot do it with our own small powers; can magic help where science fails? He feels safe to conclude a pact with the devil, because he puts into the pact an essential condition: "If to the fleeting hour I say, Remain—thou art so fair, remain!" then the "fatal chain" shall be closed. To rest in a static end of fulfillment is impossible even with the help of Mephistopheles. Knowledge and beauty are aims for which we can strive, but we cannot have them and make time stand still. Nature is process, every hour is fleeting and cannot remain.

I have outlined the dominant strain among the many implications of the Faust story. Goethe's Faust learns to abandon despair. Ignorance would remain our fate if by knowledge we meant the identity with the Spirit of the Earth. The initial problem has no theoretical solution, but we can find the practical way which starts from and through the strife for the absolute "which almost burns my heart". The search for the absolute is at the roots of research. The power to persist in it cannot be gained from an abysmal source outside of nature.

There is another legendary figure to show us that we have no extra-natural force by which we could pull ourselves out of nature yet still be in it and at one with it. This legendary figure is the Baron von Munchhausen, not the real Hieronymous Karl Friedrich von Munchhausen, born in 1720, but the hero of the stories, told probably by Rudolph Erich Raspe (1737–1794), and revived with various additions after 1785 (11).

On one of his "marvellous travels and campaigns", the Baron found himself in marshy country. The ground was dangerous, and suddenly he found himself sinking in the bottomless marsh. Instead of being frightened, he simply grabbed himself by his hair and, strong man that he was, pulled himself out to solid ground.

There is little reason to surmise that this story was invented to illustrate the process of research. Now that we have the story, we can let it serve the unforeseen purpose. It is a lesson for all those who may have felt mankind had exhausted its reservoir of inventiveness. Miraculously, the reservoir proved inexhaustible. Man has creative forces which are beyond mechanical analogies. Mentally, we all follow Munchhausen's example in spite of its physical impossibility.

Experiment and Intuition

After what I said previously, it will not come as a surprise that I have to state an opposite point of view. I quote it from a passage in Immanuel Kant's polemic against David Hume (1711–1776), where Kant objects against an apparent "self-birth" of concept.

According to Kant, Hume did not distinguish between the two kinds of judgments: the one through pure understanding (Verstand) concerning that which can at least be an object of experience, the other through pure reason concerning such properties of things (or perhaps the existence of such objects) which can never present

themselves in experience. Hume "did not distinguish between these two kinds of judgments as he should certainly have done; instead he considered it impossible to increase our concepts out of themselves, something that could be called the *self-birth* of our understanding (including reason) *without having conceived by experience;* therefore, he declared all their presumed principles a priori as imaginative, and found that they are nothing but habit resulting from experience and its laws. Thus the principles a priori became for him merely empirical, i.e., really accidental rules to which we ascribe a supposed necessity and generality" (12).

Without the outer support on experience, we cannot pull ourselves out onto solid philosophical ground. The same refutation of Munchhausen's example is contained in Tobias Dantzig's thought "that it is inherently impossible to ascertain whether any universe of human discourse possesses objective reality, or is but a fiction created by man's predilections" (13). Apparently, we always return to Faust's initial problem unless we can accept the Munchhausen solution of human self-help.

The alchemists and chymical operators implored the help of superhuman forces by incantation and evocation. The shining hero of myth and legend found the outside help he needed from enchanted lions and personified forces of nature. The modern inventor entrusts the decisive help out of the morass to his own subconscious mind. Joseph Rossman quoted many examples for subconscious reactions (14). August Kekulé, Henri Poincaré, and other great men of science have experienced them in decisive moments.

Is Planning Bad?

Historically, human faculties were first inserted into the object, to endow it with love and hatred; later human identification was abandoned by creating relationships between the objects, and then the human side was recognized in a new position as the influence of the observer on the result of his experiments. Most recently, the human root of research has again been discussed, this time in form of the problem of planning.

Curt P. Richter warns: "Let us not mistake experimental design for ideas" (15). Louis P. Hammett states: "The most important discoveries have always been the least expected ones" (16). This is directed against bureaucratic planning and does not contradict the value of ideas or of "a fruitful conceptual scheme" which the psychoanalyst Sandor Radó advocates (17).

In science, "conceptual schemes" have had a very bad reputation. In certain pathological phases of science, e.g., alchemy or some of the natural philosophy of the 19th century, the scheming became extravagant, almost disastrous. Against such extremes a strict experimentation was proclaimed often without realizing that it meant just the opposite extreme to exclude idea and interpretation. As an exclusively enumerating and cataloguing account of observations, science would not have come into being. We would not have found how to increase new observations in number and accuracy if we had not applied ideas and interpretive correlations to the observed and newly called-for facts.

Strict experimentalism seems to consider facts as a pre-existing, definite quality waiting to be pulled piece by piece out of their container. The experimentalists are themselves led by a general idea and by an interpretation of the laws of energetics which excludes the creative power of imagination and idea. To men of this attitude, creative power would seem as ridiculous as the Munchhausen story.

It may be startling at first to introduce this story into a serious contemplation concerning roots of research, and yet, we have to go still further than that and consider not only this play of the imagination, but play itself seriously. The playing child recreates sounds and gestures of real events by omitting some essential realities. For example, the child will pick up a non-existing pair of eyeglasses and put them on with the same movements as it has observed in a grown-up. Not the objects but the activity, the gestures are of primary importance. At a later stage, imagination converts a piece of wire into the eyeglasses, taking a representative part for the whole. This is the root of the process of research.

In a recent published study on fiber flocculation in papermaking, spherical and cylindrical particles were used to represent the fibers (18). In biochemical or pharmacological research, we substitute an isolated nerve for the whole animal, and this is an advance from earlier attempts at representing life by simple mechanical "blocks" which we thought up to construct a more understandable image of life.

I have tried to show research as a necessary and natural growth out of roots in the urge for absolute unity. This growth leads to the unending task of finding our way between contradictory aspects of life. To solve it, we use the creative powers of imagination in play and ideas. All of this may appear itself as a play of theorizing. Theory of knowledge, under such an aspect, might be rejected as mere analysis. Against such criticism, I can cite the physicist E. M. Purcell who said, in his Nobel Prize Lecture, 1952: "It is an old story in physics that higher resolving power leads to new effects" (19). Increased resolving power in the analysis of knowledge leads to new insight into the means for obtaining new effects in research.

To nourish the roots of research, we would thus have to go to philosophy and play. The education for research starts with feeding the instinctive drives towards playing and thinking. An old Latin saying comes to mind: *Pro patria est dum ludere videmus.* Extended to our present topic, this means: We aim at great things while we seem to be merely playing.

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NWMA Standards for Millwork and Their Effect on Competitive Products[1]

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Reviews history and present status of millwork standards and lists benefits of standards to industry and consumers. Gives reasons why standards have helped the woodwork industry to hold its principal markets against competitive materials and recapture some lost markets.

Foreword

AT THE OUTSET it should be clearly understood that all standards adopted or now pending in the woodwork industry are entirely voluntary. They do not deprive manufacturers of freedom of contract with their customers. No concerted attempt is made to enforce or dictate compliance with standards. Any such attempt probably would be construed as restraint of trade in violation of state and federal anti-trust laws, as would also any agreement among manufacturers to limit production to standardized items. Any manufacturer who elects to manufacture and sell non-standard products is free to do so. However, experience proves that a reasonable and well-publicized standard which holds tangible benefits for the manufacturer as well as his customers, is usually adhered to either voluntarily on the part of the manufacturer or because his customer orders goods with the understanding they shall comply with the standard.

In its standardization activities, the National Woodwork Manufacturers Association has favored the commercial standard program rather than mere industry standards. Commercial standards are initiated and written by industry but the actual submission for acceptance to industry and the consuming public is done by the Commodity Standards Division of the U. S. Department of Commerce, as is also the final promulgation and publication of the finished product. Hence the commercial standard, when finally approved and published, takes on added dignity and prestige because it is a government document. Here, also, an important legal policy is involved. Attorneys for the National Woodwork Manufacturers Association have frowned upon standardization activities which are based solely upon industry standards. Such standards are frequently criticized as being arbitrary or capricious and have even been attacked as attempts to restrain trade. But after a standard has successfully run the gauntlet of the industry, the trade, large consumers, and several government agencies including the Department of Justice and the Federal Trade Commission, and is approved and published as a commercial standard by the Department of Commerce, it is doubtful if anyone could successfully attack it as being in restraint of trade.

Most commercial standards include these principal sections: Purpose; scope; general requirements; detail requirements; grades; tests; standard sizes; inspection and grade marking; method of ordering; and nomenclature and definitions. This, you will note, gives comprehensive coverage of the essential properties and specifications every good standard should embrace.

History and Present Status

Stock woodwork (or stock millwork) is the subject of all standards sponsored by NWMA. Stock woodwork embraces building products manufactured by mass production methods in standard sizes and designs for stocking by wholesale and retail distributors. The principal stock woodwork products are windows, sash, doors, frames, screens, and cabinets. The designs and sizes of stock woodwork follow public preference and demand rather than precede it. By way of contrast, woodwork which is made to order for specific building projects is generally known as special, custom, architectural, or detail woodwork, and is not embraced in NWMA standards.

Stock woodwork made its first appearance in this country about 1840 to 1850 as the result of public demand for building products of standard sizes and designs which could be mass-produced and mass-distributed. Hence the first standards in the stock woodwork industry made their appearance in the form of catalogs published by individual manufacturers which gradually came to be recognized as industry standards. Hence for nearly 100 years the only standards the industry could boast were those originated by the industry itself without reference to or collaboration with any official or quasi-official standardization organizations such as the Commodity Standards Division, the American Standards Association, or the American Society for Testing Materials.

The first commercial standard initiated by NWMA related to ponderosa pine stock doors. Application and the first draft were submitted to the Commodity Standards Division, U. S. Department of Commerce, on December 30, 1943. After processing and circulation throughout the industry and consumer groups for acceptance, it was approved and published as Commercial Standard CS 120–44 on August 15, 1944, effective September 15, 1944. Since then it has been revised three times, the current revision being designated as CS 120–53.

Other existing commercial standards which were initiated by NWMA are: CS 163–52, Windows, Sash & Screens; CS 190–53, Double Hung Wood Window Units; CS 193–53, Insulating Glass Windows & Sash; and CS 171–50, Hardwood Veneered Doors.

Four additional proposed standards are now in the hands of the Commodity Standards Division for processing as follows: Door & Window Frame Standard submitted November 5, 1953; Casement Window Unit Standard submitted January 25, 1955; Awning & Projected Window & Sash Units submitted January 31, 1955; and Hollow Core Flush Door Standard submitted October 12, 1954.

Two standards have been pending for some time but have not yet been submitted to the Commodity Standards Division as follows: Resin-Bonded Wood Particle Board; and Water Repellent Preservative Treatment of Woodwork.

The campaign for better coordination of building products was launched

[1] Presented at meeting of Midwest Section, FPRS, April 11–12, 1955, in Urbana, Ill.

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in 1939 known as "modular coordination" under American Standards Association Project A62. It was sponsored by the American Institute of Architects and the Producers Council, Inc. Realizing that windows, sash, and doors were destined to play an important part in that project, NWMA took the leadership in standardizing the sizes of windows, sash, frames, and doors to harmonize with modular measure and design. During 1945 NWMA published and distributed Manual WSS–45 as a new proposed national standard for windows and sash. The sizes embraced in the standard were in harmony with modular design based upon the 4-inch module, and sought to substitute the modular standard for the dozen or more regional or local standards of windows and sash. About four years after the original distribution of WSS–45, an application was made to the Commodity Standards Division for a commercial standard patterned after WSS–45 which was eventually approved and published as CS 163–52.

Although a modular standard for stock doors has been contemplated for several years, it has not yet been formally proposed because of lack of standardization in the location of the finished floor line and the lack of standards for related building components which would affect the sizes and location of door openings.

Benefits to Industry

How has NWMA's standardization program benefited the stock woodwork industry? Here are the principal benefits:

1. Mass production and mass distribution can be accomplished only with standardized products. For example: High-speed woodworking machinery with a single setting can be run for hours without a change in the setting when running standardized parts. Non-standard sizes would require frequent machine changes. The time saving is tremendous with standard parts.

2. Reduction of waste. Efficiency is improved all along the production line.

3. Standards are maintained by means of quality control and the use of standard test methods.

4. Test methods require research. Research means industry progress.

5. An industry has pride in the standards it has worked out for itself and is apt to adhere to them more closely than regulations imposed by an outside agency.

6. Standardization reduces and simplifies stocks and inventories carried by manufacturers and distributors; affords rapid turnover.

7. Quicker deliveries are assured.

Here is a good example of the benefit of research in the promulgation of test methods. While preparing the so-called wet and dry test and the boil test for hardwood plywood and for hardwood doors, NWMA sponsored a research project by the U. S. Forest Products Laboratory which furnished excellent data as to the behavior of the components of a door under severe exposures. Such data are now used as guides in door manufacture.

Benefits to Consumers

1. Standardization reduces the cost of the finished product; reduction estimated to be between 10% and 25% in the manufacture of windows and sash.

2. A known standard of quality results from standardization.

3. Establishment and definition of uniform grades protects the consumer against substitutions of quality.

4. Official grade marks provide the consumer with a means of easy identification. *Grade marks give the product a pedigree.*

5. Standardization brings order out of chaos and eliminates confusion.

6. Ordering procedures are simplified by standardization. For example, a 1-line reference to a commercial standard takes the place of many pages of specifications—and does a better job.

7. Standard stock woodwork is readily available in every community of the United States at the time and in the quantity required.

Standardization of stock woodwork has been an important factor in helping the woodwork industry to hold its principal markets against competitive materials and to recapture some of the markets it has lost in past years. Following is a brief discussion of the reasons.

NWMA standards always accent *quality*. Only quality goods can be successfully merchandised. Hence quality woodwork standards are valuable tools for effective advertising, promotion, and sales against the high-powered and skillful campaigns of competitive materials.

Using the several quality guarantees in woodwork standards, the woodwork merchandiser can show his customer the superiority of woodwork over alternate materials.

The several benefits to the consumer outlined above (not the least of which is low cost) give the consumer a logical reason for preferring standardized woodwork to competitive products.

Governmental organizations concerned with home construction such as FHA and VA have found that the mortgage banker and the home owner are better served by using standard quality woodwork than competitive products of unknown quality.

Approval and promulgation of woodwork standards as commercial standards by the U. S. Department of Commerce give dignity and recognized standing to those products; and induces their ready acceptance even in the face of stiff competition.

Publication of NWMA standards in Sweet's Architectural File and other publications adds to the dignity and prestige of the products they embrace and makes them readily acceptable.

Conclusion

For the reasons briefly described, NWMA believes that its program of standardization has greatly benefited the industry and the consuming public, and has become an effective sales weapon against the vigorous campaigns of competitive materials. For these reasons, if for none other, this standard program has returned full value for the investment it has involved.

Blower System Design and Installation

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MANAGEMENT IN ALL PROGRESSIVE woodworking plants is well aware of the importance of correct blower system installation. It is well understood that the only safe means of installing a blower system is to have it done by engineers thoroughly acquainted with the work. Since it is important that shavings, chips, and dust produced at woodworking machines be transported as short a distance as possible and as directly as may be consistent from various machines to the fan housing, it is important to make a floor plan of the plant, showing locations of all machines. Superimposed on this plan can be all horizontal runs of blower piping and all machines, including the main suction duct and an indication of the fan in its selected location.

How The Designer Proceeds

This plan must be carefully drawn to scale by a designer, sent to the factory by a firm specializing in such equipment. It will usually show the area and location of the shavings fuel bunker, in or adjacent to the boiler house, if it is intended to burn the wood waste. It is also necessary to draw an elevation of the proposed installation in most cases. On this elevation, height of fan installation, height of the cyclone separator, etc., can be clearly indicated. Using such drawings, it is a simple matter to design and make the entire system at the blower system factory, in units of such size as can be advantageously shipped to the point of erection.

The engineer or designer who makes

Fig. 1.—View of automatic stroke belt sander operating in plant of United Furniture Corp., Lexington, N. C. Note how hoods at both ends of the machine are connected to the main overhead duct by flexible tubing. Photo courtesy of Mattison Machine Works, Rockford, Ill.

preliminary drawings generally numbers the various machines as shown on the floor plan, and makes a numbered listing or schedule directly on the drawing. Certain notations relative to each machine are made in connection with each machine number, which are pertinent and necessary knowledge for proper development of the system as a whole. A certain amount of capacity is necessary in a blower system for each machine served, both in reference to diameter of pipes involved and amount of suction which must be present in those pipes.

Each woodworking machine of a type which carries knives on cutterheads will have the number of cutterheads noted on the drawing, together with maximum length of knives which can be used on each cutterhead. The maximum length of knives which can be used on a cutterhead has a definite bearing on diameter of the suction pipe which must be provided to adequately serve that cutterhead. Each cuterhead must obviously be provided with its own hood and blower-system connection.

Branch pipes lead out from the main suction duct of the blower system to the various machines. Each of these pipes must be of adequate diameter to carry the maximum amount of shavings that will be produced by a cutterhead or other unit it serves, without any choking up or other trouble. The hood connection proper must necessarily be of the same diameter. All these are matters which may safely be left to an experienced blower engineer.

Flexible Tube Connections

One interesting aspect of pipes leading to modern blower systems is that flexible tubing may be employed in some cases to connect a machine to a main duct. This often becomes particularly advantageous where distance from machine to main duct is short, and where, by using flexible tubing, short-radius curves in suction pipes can be avoided.

Flexible tubing can be used in connecting different types of woodworking machines. One place where it seems highly advantageous is on different types of sanders. Sander dust is somewhat more difficult to remove cleanly than most forms of woodworking waste, because its fineness causes it to pack in various cases. An example of flexible tubing use is seen in the accompanying photograph, where an automatic stroke belt sander has been connected in this way.

Air Pollution Control and the Forest Products Industries[1]

E. S. FELDMAN[2]

Executive Secretary, Furniture Manufacturers Association of Southern California

Discusses the various ways in which forest products industries contribute to air pollution through methods of incineration of wood wastes and manufacturing processes. Indicates means to reduce air contamination, including development of new uses for wood wastes.

THE MATTER OF DIRTY AIR, it seems, will be here a long time. One of the more optimistic guesses states that it will be present not less than ten or fifteen years (1)[3]. There is no need here to go into the history of air pollution nor into the attempts to control it. The JOURNAL OF FPRS has carried some references to these matters (2) and other information on this subject is readily available (3).

This history, however, does reveal some instructive lessons. These should be carefully heeded and absorbed by the forest products industries because it is apparent that any community, when it becomes sufficiently industrialized or when the population increases to a given extent, is subject to air contamination (4). The extent to which this contamination becomes a nuisance depends upon the nature and quantity of the contaminants, and the geographical, topographical and meteorological conditions of the area (5). No community which pretends to any consequence, then, can be assured that it will not be affected with the unhappy results of undue atmospheric contamination: decreased visibility, eye irritation and lacrymation, throat irritation, nauseating odors, and ultimately the destruction of vegetation, human, and animal life (6).

We have all heard of the problems of Pittsburgh, St. Louis, Chicago, and Los Angeles, to name but a few cities coping with smoke, smog, or smaze, while the London and Donora disasters are still fresh in mind (7). Let no one think he can escape this symbol of our civilization (8). In the Pacific Northwest, for example, observe the growth of noisome air contamination (9).

All phases of the forest products industries should be concerned with the problems of air pollution. In every stage of these industries there are opportunities for dirtying up the atmosphere: burning the wastes accumulated in logging operations, and doing the same thing, for the most part, with lumbering wastes; in processing lumber into usable or consumable items, wood wastes are produced and finishing materials are added which create other air pollution difficulties; the retailers and ultimate users of the completed items crease wastes in the destruction of packing cases or of the items themselves; and through all these many processes of getting the raw materials into a shape to be used, the diesel and gasoline engines used in transporting the raw materials, men, and products are helping make the whole situation even more trying (10).

Processes Leading to Air Contamination

A. Disposal of Wood Wastes: As mentioned above, at every phase of the life (11) and use of the tree, there are opportunities for the creation of wood wastes and consequently of air contamination. It does not make much difference how or at what stage these wastes arise, for the problem is the same in each case: how to get rid of them? More precisely, the problem is: how to get rid of them without dirtying up the atmosphere?

B. Some Solutions to Wood Waste Disposal: *1. Open Burning* — Open burning of wood wastes is still a frequent occurrence throughout the United States near lumber mills and yards, furniture and fixture plants, etc., and this technique is common in disposing of household refuse. However, in due time this method of waste disposal for commercial and industrial plants will be doomed (12). The fire hazards and the air contamination that result from open burning are obvious. Wood makers and wood users should plan their operations with this restriction in mind.

2. Heat and Power—Utilization of wood wastes as fuel might be deemed an obvious course for consuming the millions of BTU's available and they are so consumed in many parts of the country. But this is not as simple a process as it sounds. In the Los Angeles area, wood waste is not used for fuel because there are no facilities available to harness this great release of heat, and the facilities have not been created because there has been no need for the heat. Besides, there are sufficient quantities of low cost fuel oil and natural gas for small needs. Furthermore, the users of the heat in that area are so widespread that central heating systems are not economically feasible and the producers of the wood wastes are so scattered that collection of the wastes to a central place is an obstacle which cannot be overcome economically.

Even those factories which are able to utilize all their wood wastes during the colder parts of the year find they have a disposal problem when the heat is no longer needed. They are then faced with the disposal of the wastes by other methods.

3. Incineration—This is disposal of combustible refuse, including wood wastes, by burning. For the most part, industrial incinerators are of a single chamber, silo or wigwam, type. These incinerators are almost characteristic of the West Coast (13). However, they are little more than enclosures for bonfires and they are entirely inadequate in an area which may be suffering from air pollution since there is little opportunity to control the three "T's" of combustion: temperature, time, and turbulence (14).

As a matter of theoretical and academic consideration, the single combustion chamber incinerator could be made to work under a system of careful feed and control, but it may not

[1] Presented at Session IV, Smog Control, Electric Drives and Wood Preservation, FPRS Ninth National Meeting, June 21–24, 1955, in Seattle, Wash.

[2] The author wishes to acknowledge the invaluable assistance of Robert L. Chass, Los Angeles County Air Pollution Control District, in the preparation of this paper.

[3] Numbers in parentheses indicate references listed at the end of the article.

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be economical to do so in the small mill or plant where there is an erratic feed in type and amount and where only casual attention is paid to the burning operation. If these incinerators exist at all, it is because they are relatively cheap and simple to build and maintain.

Eventually these single chamber incinerators will not be used, at least in heavily industrialized areas. For some time the Air Pollution Control District of Los Angeles County has not permitted the construction of such incinerators and it appears to be the objective of the Board of Supervisors of that county to ban all existing single chamber incinerators.

To the extent that incineration is still to be used, it will have to be accomplished in properly designed multiple chamber incinerators (15). But as these incinerators are not inexpensive either in construction or operation, they may spur other solutions to wood waste disposal.

4. *Land Reclamation*—This is the disposal of combustible refuse by burying the refuse in the earth. Holes or cuts may be man-made or they may be natural valleys. They are filled with refuse and then covered with earth.

Users of this method of wastes will, of course, have to collect wastes in piles or bins and transport them to the site. This represents some expense, although probably not an overwhelming amount.

While the site in many cases will be provided by the community, there will be instances where the users have their own land to be used for this purpose. Land reclamation eliminates any fire hazards present in burning, provides a cleaner operation of the plant, and definitely results in no air pollution. When properly managed (16) the land can be ultimately used for any but the heaviest types of buildings, for access roads, and for almost anything else for which land is needed.

On the other hand, the bulk of the refuse requires much space and presents difficult problems of transportation. While these disadvantages may make the "cut and fill" method uneconomical, they do not make it any less desirable as a technique of waste disposal.

5. *Utilization*—This is not a paper on wood waste utilization. The literature on this subject is stupendous. Nevertheless, there is still no simple method by which wood wastes can be turned into something useful in a relatively inexpensive way without the necessity of transportation to another site, the separation of hard from soft wood, of moist from dry wood, of blocks from sawdust and shavings. A fortune awaits the solver of this problem, for it has been estimated that there is anywhere from 2,000 to 5,000 tons of wood waste burned daily in Los Angeles County alone.

6. *Elimination of Wood Waste by Better Design and Operation*—The reduction of wood waste produced would seem to have tremendous potentialities. Users of lumber, by more careful design or the use of dimension cut stock, may reduce the amounts of blocks, sawdust, and scrap produced when using rough lumber (18). Two limitations suggest themselves on the surface, however: first, the increased individual plant cost of using either more adequate design or dimension cut stock, and, second, the greatest part of the wood waste is not made by the lumber users, but by the lumber mills.

C. Air Conveyor Systems: The air conveyor systems are designed to remove shavings and dusts from the machine work areas to open piles, bins, incinerators, or boilers. For the most part, this is all they have been designed to do. They get the wastes away from the machine, but frequently the particles go into the atmosphere instead of into the bin, incinerator, or boiler.

If the cyclone, which is part of the air conveyor system, is not designed with air pollution control in mind, it will fail in a vital way. A good job can be done here to eliminate air contamination at little expense to industry through proper design and operation of air conveyor systems.

D. Finishing Operations: The finishing operations in wood processing plants also give many opportunities for atmospheric pollution. Lacquers or thinners are hydrocarbons, some of which have been found to be smog-formers (19). There is a possibility that current research will prove that all such emissions are undesirable pollutants.

Paint spraying will release paint particles which may damage property. Water wash systems are easily installed, however, and this difficulty can be readily solved.

Odors may accompany lacquer spraying. If the operations take place near a residential area, these odors may be objectionable. Here, the more congested an area is the more stringent may be the controls. It is entirely possible that in the future all spraying operations will have to be equipped with fume burners so that all traces of particulates and odors are completely destroyed.

E. Transportation: Moving the commodities resulting from each of the forest products industries processes is frequently accomplished by motor vehicles. These may be of two types: diesel engine and gasoline engine.

Forgetting the chemical contribution of the diesel engine to the total air pollution problem, the effects of a smoking diesel engine are readily apparent to anyone who has followed one of them on an upgrade. And proper maintenance of equipment and insistence upon better education of diesel drivers provide ready and simple answers. The drivers may have to be more careful and work harder, and they should have mirrors properly placed to see the stack emissions, but these conditions are not reasons for permitting contamination from this source to continue.

As to the gasoline engine, the experience in Los Angeles County is instructive. Studies by the Los Angeles Air Pollution Control District indicate that 1,000 to 1,200 tons of hydrocarbons from the daily burning of gasoline in more than 2,000,000 automobiles and trucks are exhausted into the air each day. Tests also show that these emissions include a sufficient concentration of smog-producing hydrocarbons to create smog effects.

The conclusion, of course, is clear. These hydrocarbons must be eliminated. While engineers agree that this can only be accomplished by controlling automobile exhaust fumes, development of means for accomplishing this objective presents several problems.

Thus far it appears impracticable to attempt to absorb these gases, as any device or chemicals used for the purpose soon would become saturated and would require frequent changing. This would be expensive, troublesome, and would not lend itself to enforcement. The alternative appears to be to achieve complete combustion in the exhaust system. Many comprehensive research projects are under way by the Los Angeles County Air Pollution Control District and other organizations to develop feasible remedial equipment of this type. Expense and excessive conditions of heat are the chief difficulties that still require correction.

Possibly the automobile manufacturers will be able to develop a shut-off valve for the carburetor to prevent the release of unburned gasoline during the deceleration cycle, which accounts for more than 50 per cent of the total discharge of unburned fuel into the atmosphere. Other research and studies are being undertaken by the Automobile Manufacturers Association and presumably, sooner or later, correct answers will be found.

Conclusion

From the foregoing, it is fair to conclude that the forest products industries, no matter where they are located and no matter how they fit into the chain of raw materials to consumer satisfaction, have to face the realities of air contamination and its control. At every link in this chain, opportunities abound for being or becoming a "smogger" (20).

It is obvious, too, that these industries have a responsibility to the community to prevent this contamination of the atmosphere. No longer can these industries keep producing and stand aside, letting the harm fall where it may with impunity. Even if there were no legal responsibility, there is the responsibility established by the fact that it is an integral part of the community.

Industry in the past has not as a whole considered the obligations it has created by virtue of its existence and has, consequently, had these obligations forced upon it by public opinion backed up by law. To the extent that industries shirk their obligations in air pollution control, they shall surely have legislation to impress them. In many places that legislation is already here (21), and unless they choose to shoulder their responsibilities, they may anticipate more such legislation.

As to public relations with the community, it is clear that those who spend considerable sums of money over the years in building up a desire for their products and good will for their organizations can lose both in an amazingly short time when the community becomes irritated by the dirty and possibly noxious air. As one student of this subject has remarked (22): "In this day, no company can afford to think of itself as something apart from the people of the communities in which it operates. Their welfare and its welfare are closely bound up together. The people of the community have a perfect right to expect good industrial manners, even though it is obviously impossible, in an industrial civilization, to have our air and water as pure as they were when the country was only inhabited by Indians."

Forest products industries can do something about air contamination if they will only think about it at the same time as they think about any other aspect of their factory, plant, mill, or equipment. They should develop an *air pollution attitude* as they have a *functional attitude* on plant and equipment. If they will think of an incinerator not only as a device for burning, *but as a device for burning which will not pollute the air* they will be making great strides. If they will consider a spray booth or truck not only as a device for finishing our products and delivering them, but as a nuisance to their neighbors *and their customers,* they will have started well along the road to retrieving and retaining some purity of the air.

Industry should not always wait to be compelled by legislative fiat to act. Here is a golden opportunity for industry to solve the problem with the aid of government, but without its compulsion, if it acts fast. Remember, a smoking stack is no longer a necessary concomitant to prosperity.

To paraphrase a slogan of the Air Pollution Control Association, it is better to be a part of the solution than a part of the problem.

References

1. Drs. Harold E. Orford and Raymond M. Manganelli of the Rutgers University Department of Sanitation, quoted in New York Times, January 8, 1955, p. 15. An Ad Hoc Interdepartmental Committee on Community Air Pollution established on the invitation of the Secretary, Department of Health, Education and Welfare Division, in accordance with a request from the Office of the President in a report entitled, *The Federal Role in the Community Air Pollution Problem,* dated April 8, 1955, which was released June 12, 1955, stated that it will take five years and twenty-five million dollars to fill the gaps in scientific knowledge about air pollution. This report is significant in setting out principles of the relationship of the federal government to state and local responsibility for community air pollution control.
2. Chass, R. L., and Feldman, E. S., Incineration of Wood Waste in the Los Angeles Area, Journal of the Forest Products Research Society 1:135 (1951).
3. As a major source of such information on this subject, see the publications of the Air Pollution Control Association.
4. And it may be added that the complexities of our modern society due in large part to congestion of industry and business impose an ever increasing demand for individual concessions to the common good. Heber, J., in Board of Health v. New York Central R. Co., 4 N.J. 293, 298, 72A. 2d 511, 514 (1950). Judge Mark Brandler of the Los Angeles County Municipal Court has referred to this contamination as "aerial scum." People vs. Niegosch and others, Criminal Case No. 33406, February 18, 1955.
5. Chass, R. L., and Feldman, E. S., Tears for John Doe, University of Southern California Law Review 27:349 (1954).
6. The man-made air pollutants may be classified as smoke, dusts and fumes, sulfur dioxide and hydrocarbons. The methods of control of smoke, dusts and fumes present no overwhelming theoretical difficulties. The problem is merely one of equipment (filters, water washes, dust collectors, electrostatic precipitators, and so on) or the controlling of the processes leading to the creation of the pollutants. The gases are something else again. When sulfur dioxide combines with oxygen, sulfur trioxide is formed and it has been found that a mist composed of SO_3 and moisture will be responsible for about one-third of the total reduction in visibility at any given time. And it is known that sulfur dioxide itself will have a deadly effect on plant life.

   The lower aldehydes in the atmosphere (in Los Angeles, for example) contribute to certain undesirable characteristics of air pollution. So do organic acids. But the amount of these directly traceable to sources is not sufficient to produce the quantity measured in the air. It appears that additional quantities of these are found in the atmosphere. The same process will be noted in the case of organic peroxides. The conclusion follows that the additional amounts of these gases are created by interreaction of certain pollutants in the air. And it appears that when certain hydrocarbon vapors, such as gasoline vapor, are oxidized in the presence of sunlight, these gases are created. The reactions are aided by oxides of nitrogen in concentrations present in the atmosphere. Consequently, unsaturated hydrocarbons may be designated as contaminants. *Second Technical and Administrative Report on Air Pollution Control in Los Angeles County, 1950–1951,* Section III; Chass and Feldman, supra, note 5, pp. 357–358; Haagen–Smit, A. J., and Fox, M. M., "Photochemical Ozone Formation with Hydrocarbons and Automobile Exhaust," Air Repair 4:105 (1954): "These investigations show that automobile exhaust gases are capable of forming ozone in the air and are therefore to be considered as a definite source of smog." p. 136.

   While these emissions are relatively harmless at the point of origin, they may become quite harmful when they are oxidized as described before. This is a significant point of departure in the whole study of controlling air pollution and it is one of the great contributions to the solution of the air pollution problem made by the Los Angeles County Air Pollution Control District and its researchers.

   The Ad Hoc Interdepartmental Committee on Community Air Pollution referred to in note 1, supra, touches on this frame of reference, also: "In seeking an approach to the control of community air pollution it is not enough to collect substances from polluted air and determine their nature chemically—and then seek ways and means of reducing the amounts of these materials in the air. Many of these compounds *may* be only the spent and innocuous end products of reactions which occur between unstable substances that may be the real causes of the damage to living organisms. A knowledge of the chemical components of pollutants while they are air borne, of the catalytic substances present, of the reactions which occur, and of the shifting equilibria which are reached under varying conditions will be necessary in identifying offensive agents, and in developing methods of nullifying them." *The Federal Role in the Community Air Pollution Problem,* p. 13.

   With reference to the relation of air pollution to the safety of human life a quotation from the *Initial Report of the Air Pollution Study Project of The California Department of Public Health* (March, 1955) is pertinent: "Critical analysis of data on the question, 'How Much Air Pollution Can We Tolerate?', reveals mainly the paucity of our information. Man's ability to tolerate chemical pollutants for short periods depends largely on his physical condi-

tion, age, degree of activity and state of health. Individuals in good health can tolerate without injury greater amounts than those in poor health. Young children by virtue of their incomplete environmental adaptation, and the aged with their lessened powers of regeneration seem to be most sensitive. To answer the question of how much we may tolerate over long periods of time requires more data and intensive study. We cannot now estimate the result of repeated insults to the body acting insidiously but having no apparent immediate effects. To recapitulate, do we know how much air pollution we can tolerate? We do not. However, the indications are serious enough that we ought to find out as soon as possible." p.41.

7. See, for a brief description of air pollution disasters, Chass, R. L., and Feldman, E. S., "Tears for John Doe," Supra, note 5, at pp. 351 et seq.

8. The President of the United States recognized the seriousness of the situation in his message to Congress of January 31, 1955, in which he outlined his thoughts on air pollution: "Step up research on air pollution. As a result of industrial growth and urban development the atmosphere over some population centers may be approaching the limit of its ability to absorb air pollutants with safety to health. I am recommending an increased appropriation to the Public Health Service for studies seeking scientific data and more effective methods of control." Senator Thomas Kuchel together with other Senators, responded by introducing S. 928 to this end at the first session of the 84th Congress.

   What extreme public pressure and fear can ultimately lead to is exemplified by regulations soon to be adopted by the Los Angeles County Board of Supervisors relating to "Emergencies," by which, when pollutants in "dangerous toxic concentrations" are detected in the atmosphere, "alerts" will be sounded and the Air Pollution Control Officer will take "all necessary steps to reduce the concentration of contaminants and protect the health of the public." Proposed Regulation VII to the Rules and Regulations of the Los Angeles County Air Pollution Control District.

9. Air pollution control programs in the Pacific Northwest are described by Kusian, R. N., "Planning a State-Wide Air Pollution Advisory Service," Air Repair 4:49 (1954); and Green, C. E., "Air Pollution Control in Oregon," Air Repair 2:49 (1952). For global aspects of air pollution see Went, F. W., "Air Pollution," Scientific American 192: p. 63, 65 (1955): "Smog is a function not only of the hydrocarbons released into the air but also of geography and the pattern of air movement. The height of the inversion layer and the horizontal air movement over a city determine the volume of air in which the emitted air pollutants are contained, and consequently determine their ultimate concentration. In cities which have a low inversion ceiling on many days of the year and in which there usually is little wind, the smog problem is most serious. This condition exists typically in Los Angeles, San Francisco, Sao Paulo and Rio de Janeiro. All these cities are located near the sea in areas with stable air masses and are closed in by mountains which prevent lateral air drainage."

10. Chass and Feldman, supra, note 4, 368–9; address by Chayne, C. A., "Motor Vehicles and the Air We Breathe," Semi-Annual Technical Conference, Air Pollution Control Association, Los Angeles, California, November 4, 1954.

11. According to Dr. Went, supra, note 9, the blue summer haze, or "natural," as opposed to "man-made" smog is in part a function of the volatile organic compounds given off by all vegetation.

12. Thus the Los Angeles County Air Pollution Control District has adopted appropriate rules and regulations to end open burning in the Los Angeles Basin after September 30, 1955, unless it is specifically exempt by law or when variances are authorized.

13. The Los Angeles County Air Pollution Control District (Smog Brief No. 12) has prepared the following tabulation of incinerators and rubbish burning in them in Los Angeles County as of May, 1955.

Type of Burning	Estimated Number of Incinerators	Estimated Tons Burned Per Day
Single Chamber Incineration	1,520,000	9,200
Multiple Chamber Incineration	500	100
Municipal Incineration	11	1,500
Open Fires	Unknown	3,000
Total		13,800

14. Chass, R. L., and Feldman, E. S., "Incineration of Wood Waste in the Los Angeles Area," supra, note 2, p. 150.

   Exhaustive studies by the Los Angeles County Air Pollution Control District reveal the following data on particle size of emissions from a wood burning incinerator (silo-type):

Size of Particles Emitted	Per cent of Total Emissions
0– 5 microns	15.7
5–10 microns	20.3
10–20 microns	21.9
20–44 microns	25.7
44 microns and over	16.4

   Particles smaller than ten microns are not visible to the unaided eye and their rate of settling is so slow that they remain in the air for days. No less, therefore, than 36 per cent of the emissions remain in the atmosphere a considerable length of time, while the particles in the "twilight zone" of 10–20 microns also probably remain in the atmosphere no little time, making the final total of emissions remaining to do harm quite large.

   Other tests show that for each ton of wood material burned, an average of 20 pounds is lost to the atmosphere. In addition to this particular matter, other products of the combustion of wood in incinerators are aldehydes, ketones and acids. But we do not need the chemist or engineer to tell us that our eyes will burn and smart when we stand in the path of smoke from a smoldering or partially burning pile of wood waste! Los Angeles Air Pollution Control District, Annual Report, 1949–1950, pp. 11, 32.

15. Principles of multiple chamber incinerator design have been set out by Chass and Feldman, supra, note 2, at pp. 141, 142.

16. For example, not less than three feet of dirt must be thrown over each day's receipts of refuse. See generally, Rawn, A. M., and Bowerman, F. R., "Engineering Waste Disposal to Prevent Air Collection," Journal of the Air Pollution Control Association 5:10, 12 (1955).

17. See, for example, the Technical Information Service Report No. 7 of the British Furniture Development Council, "Uses for Woodwaste."

18. See on this subject the address of Frank T. Parrish, "Furniture Design from the Standpoint of Lumber Utilization," before the American Society of Mechanical Engineers as published in Wood and Wood Products, December, 1950, p. 17 et seq. and January, 1951, p. [illegible] et seq.

19. See footnote 6, supra.

20. An apt neologism created by Louis M. Brown in his introduction to a symposium on air pollution in University of Southern California Law Review 27: 347 (1954).

21. Liberty can be lost in many ways: at one time the proposed Regulation VII to the Rules and Regulations of the Los Angeles County Air Pollution Control District, supra, note 8, provided that anyone who refused to comply with the Regulation when he had knowledge of an "alert" could be placed under arrest by the Air Pollution Control Officer, forthwith.

22. Pendray, G. E., "Public Relations Aspects of Industrial Wastes," Industrial Hygiene Foundation (1949), p. 9.

Discussion

J. B. Grantham (Oregon Forest Products Lab): How is air pollution measured?

Mr. Feldman: There is no one instrument or method which can be used as an index of total air pollution. This is especially true since each contaminant or category of contaminants will produce different effects. Hence each contaminant must be measured specifically, such as total aerosols, oxides of nitrogen, sulphur dioxide, ozene, and aledehydes. Today some of these are measured with automatic instruments. However, in some cases slow, tedious, wet chemical methods must be used. That is one of the big projects in air pollution control work—better and more adequate instrumentation.

Frank Holland (Consultant): Mr. Feldman referred to the difficulty of enforcing regulations regarding smoke nuisances. A point of interest is that before leaving England in April, I read of the work of a committee set up to investigate smoke nuisances. After October 1, 1955, it will be an offense to create a smoke nuisance in the city of London area. I am not aware, however, of any penalty for automobile exhausts or spray booth fumes, or even if the law will apply to such nuisances as these. Before fines can be imposed, some form of bill will no doubt have to be passed by Parliament; I presume this is now being dealt with.

Around the World in Forest Products Research and Development

World-Wide Forest Products Review

REVIEW OF NINTH YEARBOOK of Forest Products Statistics, prepared by the Forestry Division of the Food and Agriculture Organization, United Nations. Based on information received from more than 120 countries in 1954.

Logging

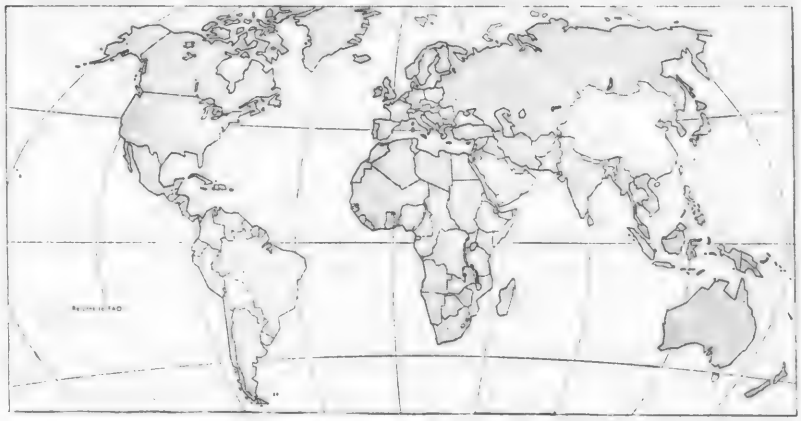
Total Fellings. Recorded removals of roundwood from the world's forests showed a further slight increase in 1954 from 1,460 million cu.m. in 1953 to about 1,500 million or about 3 per cent. This increase is almost entirely attributable to the U.S.S.R. and Europe.

Logging Categories. Although production of fuelwood for the world as a whole has remained stable since 1953, it represents a steadily declining proportion of the volume of fellings, thus conforming to the general trend for more rational utilization of forest resources. The following table shows that, in Latin America, Africa, and Asia, production is still mainly in fuelwood and that fellings of industrial wood remain relatively small:

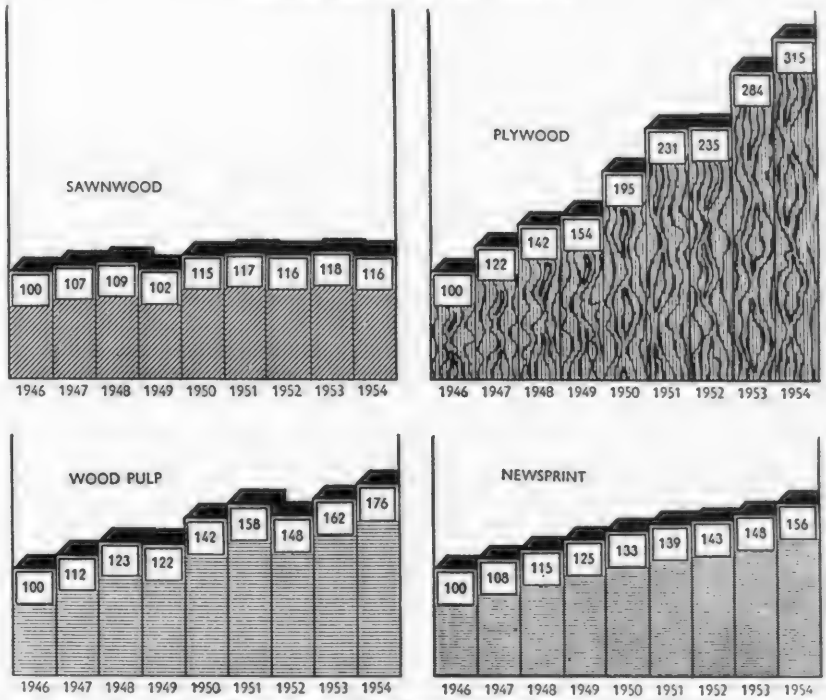
	Industrial wood	Fuelwood
	Per cent of recorded fellings	
Europe	62	38
U.S.S.R.	60	40
North America	84	16
Latin America	12	88
Africa	8	92
Asia	44	56
Pacific Area	57	43
World	56	44

Wood in World Economy. The value of output of the different forest products expressed in current prices shows a spectacular rise from 1953 to 1954 caused not only by slightly rising prices per unit, but also by an increased output of secondary forest products. This value for 1954 may roughly be estimated at U. S. $28,300 million against $26,600 million in the previous year, broken down as follows:

	Millions in U. S. dollars		
	1952	1953	1954
Products of sawlogs	11,700	12,200	12,800
Products of pulpwood	5,700	6,200	7,200
Pitprops	400	400	400
Other industrial wood	1,400	1,500	1,600
Fuelwood	2,900	2,700	2,600
Minor forest products	3,500	3,600	3,700
Total	25,600	26,600	28,300



Countries reporting to FAO, 1953–54.



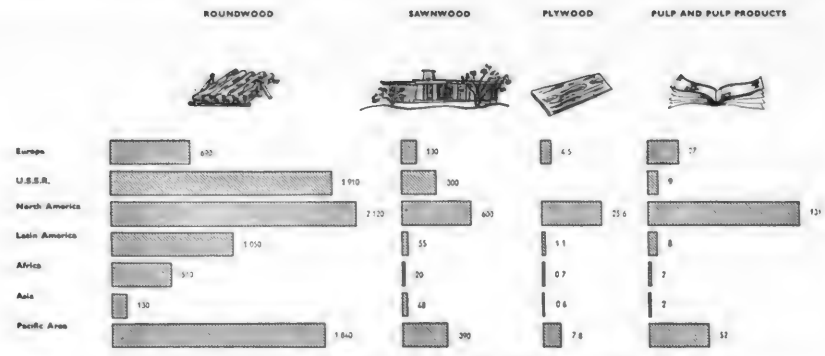
Trends in world production (15 selected countries). Index: 1946 = 100.

World Trade

The rise in trade noted for 1953 continued at an accelerated pace for all forest products during the year under review. Exports, expressed in roundwood equivalent, totaled for reporting countries 132 million cu.m., thus surpassing the 1951 record level and being 14 million more than in 1953. Exports increased for the main commodities as follows:

	Per cent
Pulpwood	23
Sawlogs	11
Sawnwood	12
Wood pulp	15
Plywood and veneers	47
Fiberboard	46
Newsprint	4

The higher volume of trade, together with a slight increase in prices, caused a substantial rise in the value of the forest products entering international trade. The value of exports



Consumption per capita (reporting countries only).

totaled U.S. $4,254 million in 1954 against $3,715 million in 1953, an increase of 15 per cent. The value of imports rose to U.S. $4,364 million against $3,843 million in the previous year. Europe and North America accounted for more than four-fifths of total reported values:

	Percentage of international trade	
	Imports	Exports
Europe	49	50
North America	32	41
Latin America	6	3
Africa	4	2
Asia	7	4
Pacific Area	2	--

Lumber

Production. World output of lumber remained stable in 1954 as compared with 1953, amounting to 269 million cu.m. against 265 million in the previous year. While the U.S.S.R.'s production is estimated to have risen by some 4½ million cu.m. or 8 per cent, the increase in Europe was about 4 per cent, whereas North America showed a decrease of 4 per cent, producing about 4 million cu.m. less.

World production of coniferous lumber, accounting for 79 per cent of the total, rose to 45.2 million standards only, about 1 per cent over the 1953 mark. Whereas countries such as Austria, Finland, France, Sweden, Canada, Brazil and New Zealand expanded their mill-outturn, others like Western Germany, Italy, Norway, Yugoslavia, United States, and Japan reduced their production. Hardwood output rose in 1954 to an estimated 57.6 million cu.m. or 2 per cent more than in the past year; a slight decrease in North America was more than compensated by bigger production in all the other regions.

Trade. A further remarkable rise in international trade of softwood and hardwood, (including boxboards) took place in 1954, reaching 30.3 million cu.m. (export) or 12 per cent more than in the previous year, surpassing the record level of 1951. Almost all the greater exporting countries extended their shipments abroad, with the exception of Sweden, Yugoslavia, and Brazil. The U.S.S.R. and other eastern European countries increased their exports to western Europe and North America by 600,000 cu.m. or 33 per cent over the previous year. The following table shows the regional balances of reporting countries for lumber (excluding boxboards):

	Net balance*			
	Sawnwood			
	Coniferous		Broadleaved	
	1953	1954	1953	1954
	1,000 cu. m. (s)			
Europe	—1,250	—2,100	—500	—500
U.S.S.R.	+ 819	+ 977	.....	+ 13
North America	+3,063	+4,125	—200	—214
Latin America	+ 24	+ 24	+125	— 93
Africa	—1,050	—1,210	+ 40	..
Asia	— 830	— 680	+510	+740
Pacific Area	— 350	— 570	+ 10	— 40

*Net exports+; net imports —.

Plywood

Uninterrupted expansion continued in 1954 and for the first time passed the 9 million cu.m. mark. World output (including blockboards) may be estimated at 9.2 million cu.m. against 8.4 million in 1953, a rise of 9 per cent. Nearly all countries showed a rise in production, particularly Japan, which in two years, increased its output by about 80 per cent. Japan is now in fourth place after the United States, U.S.S.R., and Western Germany, after having surpassed Canada.

Trade in plywood (including veneers) also expanded during 1954, reaching in reporting countries an export volume of 940,000 cu.m. against 640,000 the previous year. Finland increased its shipments abroad by about 82,000 cu.m., representing nearly a quarter of its production, and Japan's exports rose from a mere 22,000 cu.m. in 1952 to 166,000 in 1954. The United Kingdom and the United States, the two biggest importers and accounting together for 71 per cent of the reported world totals, increased their intakes by 311,000 cu.m. or 70 per cent.

Wood Pulp

Pulp output reached in 1954 an overall high of 44.0 million tons, and exceeded the 1953 production by 3.6 million tons or close to 9 per cent. Increases were noted in all regions, but percentagewise the Pacific area led all others with its increased output of more than a third. A considerable rise was recorded in countries like Argentina and Portugal, where additional capacities were installed. World production of chemical wood pulp showed an increase of 2.4 million tons or nearly 10 per cent, whereas in mechanical wood pulp it was some 7 per cent and in other vegetable fibre pulp about 8 per cent.

Paper and Paperboard

Production of all categories of paper and board increased considerably during the year under review and surpassed the former record level of 1951. Total output in 1954 was 51.4 million tons or some 6 per cent more than in the previous year. About one-fifth of the pulp products were newsprint and one-third board. North America remains the leading producer, with 58 per cent of the world's production, whereas the share of Europe and the U.S.S.R. together is only 34 per cent.

Paperboard: Output increased in 1954 by 3 per cent from 16.6 million tons in 1953 to 17.1 millions. Except for North America, where production showed a decline of 2 per cent, production rose in each region, showing an especially big rise in Latin America and the Pacific area. Australia's output almost doubled since 1952.

Fibreboard

World production of insulating board and hardboard continued its upward trend and reached a new peak in 1954 with 3.02 million tons against 2.62 million in 1953, thus showing a rise of 15%. Until 1953 the output of insulating board exceeded that of hardboard, but in 1954 for the first time hardboard output was greater, accounting now for slightly over half of the world's fibreboard total. Whereas hardboard production from 1953 to 1954 increased by 21%, insulating board showed a slower increase (10%). The main producing regions remain North America (especially the United States) and Europe (Scandinavia), which account together for some nine-tenths of the world's output. The leading producers, the United States and Sweden, increased their outturn by about 14%.

World trade in fibreboard represents about 10% of total production. Sweden alone accounts for 52% of all exports and increased its shipments abroad by 86,000 tons or 68%. Imports were more evenly distributed, although the United Kingdom, by far the leading importer, increased its intakes by 60,000 tons or 90%, accounting now for 35% of the world's reported imports.

Abstracts From Current World Literature

Forest Resources

Anon. Our nation's forests; yesterday and today—tomorrow? *Lake States Timber Bus.* 9, no. 1: 3–4 (June, 1955).

Historical information is given on the forest land of the United States at the time of the landing of the white man, and the present situation summarized with regard to national, eight other categories of federal, state, community, and industrial forests, and tree farms. It is concluded that only when timber is regarded as a crop—the amount harvested being replaced by growing stock—can America's timber resources supply continued needs, with a margin for export, new uses, and a national security. [Bul. Pap. Chem. V. 25, No. 12]

McArdle, R. E. Looking at forestry over 50 years. [Pulpwood Annual section] *Pulp & Paper* 29, no. 7: 88–90 (July, 1955).

Following a summary of conditions in the United States in 1905, the author discusses progress to the present day in the field of forestry as compared with other fields, the present situation with regard to forestry management, and the future. [Bul. Pap. Chem. V. 25, No. 12]

Heritage, Clark C. Forest products and the business of tree farming. *Chemurgic Dig.* 14, no. 5: 11–12 (May, 1955).

The objective of sustained-yield forest management is to produce the best diversified products of highest value through complete utilization of the most valuable tree crop that can be grown in an allotted time. Products evolved in the utilization of the whole log, with particular emphasis on chemicals, are discussed. [Bul. Pap. Chem. V. 25, No. 12]

Veneer and Plywood

Kollmann, F. Studien uber die Ausbeute in der deutschen Sperrholzindustrie. [Output studies in the German plywood industry.] *Holz Roh-u. Werkstoff* 12 (12), 1954 (465–71).

Draws conclusions from data supplied by 11 large West German plywood plants. The following production losses are analysed for Beech, Gaboon [*Aucoumea klaineana*] and Limba [*Terminalia superba*] plywood: losses during conversion of logs into billets, barking, peeling, clipping, drying, jointing, pressing, trimming, sanding, and final trimming of faulty panels. [For. Abs. V. 16, No. 3]

Gluing

Marian, J. E. Tra och plast: aktuella problem for limnings- och ytbehandlingsforskning. [Wood and 'plastics': current problems in gluing and surface treatment research.] *Medd. svenska TräforsknInst. (trätekn. Avd.)* No. 48*B*, 1953. pp. 12. 40 refs. [Sw.sw.] Also as *Transl. For. Prod. Lab., Can.* No. 209, 1954. pp. 14.

A conference paper—mainly a review of literature, but containing some data from the Swedish Wood Research Institute on the costs of different types of scarf joint and on the manufacture of boards and moulded materials from wood waste and resins. [For. Abs. V. 16, No. 3]

Research

Forest Products Research 1954. H. M. Stationery Office, London, 1955, 60 pp.

Work on kilning has included drying oak, Douglas-fir, balsa and African mahogany at temperatures above the boiling point of water. The Douglas-fir behaved quite satisfactorily, but the oak dried in superheated steam at 110° C. collapsed, checked, honeycombed and distorted so badly as to be rendered virtually useless. African mahogany dried rapidly without splitting at temperatures of about 100° C., but varying degrees of collapse or 'waisting' of the cross-section of boards occurred. On the loads tested this would have led to a conversion loss of 5–10% in machining. Other tests have been carried out on the effect of air speeds on drying rates and on the shrinkage of elm during drying.

Five tropical timbers, including African mahogany and sepetir, have been tested to determine their steam bending properties, but none could be considered a suitable substitute for the well-known bending woods such as beech. Large-scale bending tests showed Turkey oak, hornbeam, field maple and sweet chestnut to possess good bending properties if defects such as knots and splits were excluded. An improved technique for making hairpin-type bends with straight legs has been developed.

Investigations into timber mechanics have included tests on different kinds of joints for use in the manufacture of chair seats and tests of a number of plywoods and laminated beech boards to assist industrial firms in quality control of material in structural design.

The blunting of wood-cutting tools has been the subject of further study concerned with the change in shape and condition of the cutting edge as wear develops and its relation to such factors as the material from which the tools have been made, the cutting conditions and the properties of the timber cut. Tests have shown the importance of using the correct sharpness angle, especially with the hard-tipping materials, which need a higher value of this angle to reduce the tendency to develop microscopic fractures at the cutting edges. The quality of the finish of the cutting and clearance faces also controls the wear-resistance.

A series of tests made on quarter-sawn and flat-sawn softwoods and hardwoods showed the torque in boring to be directly proportional to the chip thickness and, therefore, to the feed speed. The thrust force is increased with the feed speed, but at a diminishing rate. Other experimental work in machining has included studies of the cutting action of saw teeth, the formation of chips in planing, and the tipping of saw teeth and cutters with various special materials.

Long-term durability tests on glues for plywood and assembly work have been continued. A great deal of basic work has been carried out on the habits, life-history and control of timber pests, including Lyctus, the common furniture beetle and longhorn beetles. [F. D. C. Tech. Bul. V. 5, No. 28]

Paddon, T. W. Timber and the microscope. Timber News Ltd., March 1955, 59 pp.

This booklet describes the way the microscope works and how it is used, and then gives details of the methods of preparing sections, staining them and mounting them. There is a chapter on drawing diagrams of the specimen seen through the microscope, another on the use of filters and, finally, one on developing a thesis. The booklet is written with the student of timber technology in mind and much of it is based on the experience which the author has gained in overcoming personal difficulties.

There are several textbooks on microscopy, but this is probably the only one which deals with the application of microscopy to wood structure at the level needed by the novice in the subject. [F. D. C. Tech. Bul. V. 5, No. 28]

Preservation

Greathouse, G. A., and Wessel, C. J. Deterioration of materials. Causes and preventive techniques. Reinhold Publishing Corporation, New York. 1954.

Three parts deal with wood: Part 1 covers important factors in deterioration (climate, chemical, physical and biological agents). Part 2 includes a section on wood and wood products (47 pp.) by *G. M. Hunt*. Part 4 deals with special aspects of preservation and includes a section on toxicological evaluation of preservatives (13 pp.) by *W. G. Cox*. [For. Abs. V. 16, No. 3]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiber board and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

FORESTRY ABSTRACTS, published quarterly by Commonwealth Agricultural Bureaux, Farnham, Royal, England, subscription price $8.40 per year. The abstracts are prepared by the Commonwealth Forestry Bureau, Oxford, England, and include a Forest Products and Utilization section. This section contains about 1,200 titles and abstracts per year from literature in some 30 languages, covers all aspects of forest utilization.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

Hatfield, I. Solvent type preservatives. *Prepr. Conv. Brit. Wood Pres. Ass. 1954,* No. 3, 1954. pp. 20.

Solvent-type preservatives have been going through a 'proving' period for ca. 20 years, and their usefulness in different fields is fairly well established. The toxicity, different properties and methods of application are described and tabulated. [For. Abs. V. 16, No. 3]

Properties

Radcilffe, B. M. The influence of specific gravity and rate of growth upon the mechanical properties of Sugar Maple in flexure. *Sta. Bull. Ind. Agric. Exp. Sta.* No. 597, 1953.

The correlations between sp. gr. on the one hand and modulus of elasticity and modulus of rupture on the other, as determined from 353 static bending tests, were found to be highly significant; the correlation between sp. gr. and stress at the limit of proportionality was significant. Simple regressions between rate of growth and the 3 mechanical properties did not show significant correlation. [For. Abs. V. 16, No. 2]

Jentzsch, H. Neuere Untersuchungen zur Klassifizierung der Brennbarkeit von Holz. [Recent investigations on the classification of wood combustibility.] *Holz Roh- u. Werkstoff* 12 (5), 1954 (197–8).

[Cf. *For. Abstr.* 14 (No. 3707); 15 (No. 4034).] The author has added a further characteristic for building materials, viz. the *Glühwert* (glow value), defined as contraction of a rod under a constant load, when exposed to a constant radiating heat during unit time. This characteristic is calculated from the formula $\Sigma\Delta = \Delta_5/n$, where $\Sigma\Delta$ is the sum of all contractions in mm.); n, the number of measurements, and Δ_5, the contraction after 5 minutes. The determination of this value is conducted in the Jentzsch ignition tester, in which a basket of refractory material is substituted for the crucible. The test rod is placed vertically in the basket and loaded (0.8 kg./sq. cm. of cross-section). The temperature in the centre of the basket is maintained at a constant level [temperature value or range not stated]. The contraction is read off on a scale. Results of measurements (Δ_5 and $\Sigma\Delta/n$) and the calculated 'glow values' are tabulated for Spruce, Pine, Beech and Oak specimens of different moisture content, either untreated or treated with a fire-retardant or wood preservative, or coated with varnish. A graph shows the contraction/time curve for an untreated and a treated rod. [For. Abs. V. 16, No. 2]

Marketing

Nomura, I. Theoretical studies on the formation of forest products prices. *Bull. For. Exp. Sta. Meguro, Tokyo* No. 72, 1954.

A detailed discussion of the factors determining price in varying economic circumstances and of the cause of violent fluctuations in the price of forest products, and the desirability and practicability of a remedy. [For. Abs. V. 16, No. 2]

Measurement

Pickard, D. E. Cubic foot scale stick. *Pulp Paper Mag. Can.* 56, no. 7: 176, 178, 180 (June, 1955).

A cube stick calibrated in half-cubic-foot intervals is described, which decreases compilation markedly and field work to a certain extent in calculating the number of solid cubic feet of wood in stacked cords. The procedure for plotting the calibrations on a graph is outlined. [Bul. Pap. Chem. V. 25, No. 12]

Seasoning

Kiln-drying schedules. Forest Products Research Laboratory, Leaflet No. 42, May 1955, 14 pp.

The major change in this revision of the 1952 leaflet consists of the addition of four new schedules, making a total of twelve. The schedules are now identified by letter in order to avoid confusion with the original schedules.

In the introduction a further factor has been added which calls for variation in schedule: the need to minimize color change in timber, and kiln schedule A is recommended where this is likely to occur.

Fourteen new timbers have been added to the list with their appropriate schedule recommendation. In the new schedules no recommendation is made for kiln conditions below 15% moisture content. [F. D. C. Tech. Bul. V. 5, No. 28]

Machining

Up-to-date woodworking machinery in Japan. *Wood Ind., Tokyo* 10 (1), 1955 (1–56).

The latest Japanese types and models of plywood, sawing, planing and other woodworking machines are described in detail, with photos; also the Auto-Dial for speedy measurement of sawn timber. Names, and in most cases addresses, of the manufacturers are given in English. There is a short illustrated section on modern Japanese furniture. [For. Abs. V. 16, No. 3]

Comley, A. W. An approach to tool steel metallurgy. *Tooling,* Vol. 9 No. 4, April 1955, pp. 37–46, 9 figs.

The purpose of this article is to provide an easily understood account of the basic nature of tool steels, to explain why, for instance, alloys of tungsten and chromium are used, and to give a simplified description of the heat treatment of various steels.

There are five main groups of tool steels: carbon tool steels, alloy tool steels, hot die steels, high speed steels and die steels for plastics mouldings. These are made by adding varying amounts of different elements to the alloys. Eleven such elements are considered and the properties which each imparts to the alloy are described.

The composition of each of the five groups of tool steels is given, together with the uses for which each group is suitable and the type of heat treatment it requires. Heat treatments applied to a carbon tool steel include annealing, normalizing, spheroidizing, hardening and tempering. The mechanical and chemical changes which take place during these processes are explained. [F. D. C. Tech. Bul. V. 5, No. 28]

Barking

Raphael, H. J. Anatomical changes in Trembling Aspen (*Populus tremuloides* Michx.) induced by the application of chemical agents to the stem. *Quart. Bull. Mich. Agric. Exp. Sta.* 37 (2), 1954 (241–7).

The results of this study suggest that bark loosening is caused by a combination of chemical and physical changes occurring in the cambial region and adjacent tissues. The collapse of newly formed xylem cells and the accompanying lacunae, in conjunction with collapse and disintegration of cambial and phloem cells, results in the formation of a belt of weakened material that can be ruptured very easily. Collapse of cells seems to be partially caused by a contraction of the whole phloem region. [For. Abs. V. 16, No. 3]

Kingston, G. L. Portable barkers. *Pulp Paper Mag. Can.* 55 (13), 1954 (239 . . . 246). (*Woodl. Sect. Index Canad. Pulp Pap. Assoc.* No. 1428 (*B–7–d*).)

[Cf. *For. Abstr.* 15 (No. 2870).] A committee of the Woodlands Section of the Canadian Pulp and Paper Association summarizes the characteristics of 21 portable barkers not known before 1950, nor improved since, under manufacturers, principle of operation, cost, weight, capacity, and crew required, horse-power and limitations. Notes are added on experiments in pretreatment of logs to facilitate barking. [For. Abs. V. 16, No. 3]

Chemical Utilization

Wiley, Averill J., Harris, John F., Saeman, Jerome F., and Locke, Edward G. Wood industries as a source of carbohydrates. *Ind. Eng. Chem.* 47, no. 7: 1397–405 (July, 1955).

Data are presented on the quantity, location, and character of wood and pulping residues in the United States. Methods for processing such residues are reviewed, and the possibilities of further industrial utilization are discussed. Increasing quantities of wood residues have been moving into pulp and coarse fiber production; there is increasing chemical utilization of pulping residues. Solid wood residues for chemical utilization are limited mainly to material unsuitable for fiber production. An interesting potential use for wood is its hydrolysis to produce furfural, acetic acid, levulinic acid, and formic acid. [Bul. Pap. Chem. V. 25, No. 12]

Wood Bending

Grossman, P. U. A. and Kingston R. S. T. Creep and stress relaxation in wood during bending. *Aust. J. appl. Sci.* 5 (4), 1954 (403–17).

Discusses the influence of deviations from the principle of superposition on the relation between creep and stress relaxation in a visco-elastic body. Pairs of small matched wooden beams were tested in bending, one of each pair at constant load, the other at constant deformation. Results for creep and relaxation are compared to determine whether the relations derived from a linear visco-elastic body can be applied to wood. The irrecoverable component of deformation appears to be non-linearly related to stress in dry wood. The departure from linearity is small in dry normal wood, although more pronounced when compression wood is present. Non-linearity in green wood seems to be of different origin from that in dry wood. Both microscopic and macroscopic compression failures gradually develop in wood maintained at constant high deformation. [For. Abs. V. 16, No. 3]

Stevens, W. C. and Turner, N. A new type of steaming retort for wood-bending purposes. *Wood* 20 (1), 1955 (10–2)

Evolved at Princes Risborough, the retort consists of an open-ended box into which the pieces to be bent are loaded in rows, with spacers separating each row so that only those portions of each piece that are to be bent are subjected to saturated steam. When used instead of the conventional type of retort, for hairpin bends (as in the backs of Windsor chairs) there is much less distortion and fracture. A similar method using radio-frequency is also described. [Cf. *For. Abstr.* 15 (No. 2898).] [For. Abs. V. 16, No. 3]

Wood Drying Committee Newsletter

The Kiln Operator's Responsibilities to Management[1]

WHAT THE LUMBER INDUSTRY needs is a better product at less cost, and that's where kiln operators enter the picture. We all agree that kiln dried lumber is far superior to green lumber, but we also know there is a limit to what the customer is willing to pay for dry lumber. If we want to sell more kiln dried lumber, quality must be improved and cost lowered. Let's analyze the ten most important cost factors in kiln drying:

1. **Stacking:** The lumber must be piled and stickered on the kiln cars so that air can circulate properly. Various methods may be used. If you stack your lumber manually, the cost will be all labor, and it's up to your skill and leadership to get the maximum work output for each man hour. If you use a mechanical stacker, depreciation, interest, taxes, and maintenance are the primary cost factors. It is just as important to keep the machine in perfect running order as it is to keep the stacker working to capacity at all times. Remember, overhead expenses accumulate whether the machine operates or not, and the larger the output, the lower the cost per thousand.

2. **Stickers:** Use only the best material for stickers, milled to a uniform thickness; you'll want to use them over and over. Handle them carefully. The larger percentage of sticker breakage occurs during the unstacking of kiln cars.

3. **Kiln Operation:** Most of these costs rest with management, and you must operate the kilns provided. Yet, you can control a substantial part of overhead, taxes, interest, insurance, and other costs by controlling the volume dried in your kilns. You can't do this by merely being there as a kiln operator for so much pay for each hour on the job. Your "know how" is your greatest asset to management. If you reduce drying time without impairing quality, you are reducing costs. These reduced costs eventually mean more business for your company.

4. **Downfall or Shrinkage:** Here are hidden costs that you can't find on a profit and loss statement. Yet, a large part of these costs can be reduced. When a shipment of green clears arrives, do you check it for splits, checks, grade, and texture? Or do you handle green clears as you would common lumber? Do you report the physical appearance of each shipment to your supervisor? Do you recommend purchasing clears from the mills that send better quality?

After you have inspected the green clears, do you let them lay around over the weekend, or do you process them immediately or store them under cover? If you don't have covered space, do you rough pile to maximum height, so that only one layer of lumber is exposed to the elements instead of several?

Shrinkage can also be controlled during the drying process. For instance, we select green clears with fine surface checks. Each check is measured and recorded, and the pieces are placed in specific locations on the kiln truck. After the charge is unloaded, each piece is again inspected. We are often unable to locate the checks. This kind of inspection should be done periodically to get information on the condition of your kilns. Never assume that all pipes, vents, instruments, etc., are in perfect working condition. Kiln drying is precision work, and the equipment must be in top condition.

"Know how" pays dividends. You can have the most modern equipment, but if you do not study it, you will always be just a mechanical operator. Knowing how to operate kilns at maximum capacity with minimum time to produce a superior product with least shrinkage is your responsibility.

5. **Unstacking:** Take care when unloading dry clears to avoid impacts that might break brittle pieces or increase seasoning checks.

6. **Increased Productivity:** How do you get more production per man hour? Plan your work in advance so that all employees are kept occupied, and keep production records. This is the only way you can learn if you are getting the same, more, or less production per man hour. It doesn't take much of a slow down to raise your drying costs. Supervise your men at the beginning and end of a shift and at the lunch period. It is your responsibility to see that the men give eight hours' work for eight hours' pay.

7. **Housekeeping:** Keep it clean! Safe, efficient, low-cost production just doesn't go with sloppy housekeeping. Sloppy places attract sloppy workers, and disorder and improper piling will cost time and money. You spend 40 hours a week in your department. It's your responsibility to keep order, but you can't do the job alone. You must lead your men and acquire their cooperation.

8. **Transportation:** Ever try to figure transportation costs? They are probably absorbed by your entire plant, but you can help lower them. Arrange your layout so that each time material is moved it is moved closer to the kilns—in capacity loads, and build your loads to capacity when you are unstacking dry lumber.

9. **Teamwork:** Teamwork is one of your prime responsibilities. Have you ever waited for material to be resawn or sorted? How many times were those delays caused because you couldn't get along with other foremen? Who pays the bill because you and Joe Blow can't see eye to eye? Your company—and you, eventually. Teamwork is vital to any organization. We must work as a unit with one aim only—to produce better material at less cost. You may have ideas that would save money. Don't sit back and wait for the big one that will save millions. Do something about it. Little improvements added together result in production miracles.

10. **Safety:** If a man in your department has an accident, lost man hours plus hospital and doctor bills can add up to a terrific sum of money. It's your job to prevent such accidents by correcting sloppy conditions and faulty equipment. You must teach your men the proper way to lift, to watch out for falling lumber, and to watch sliver injuries. You must provide goggles when they are needed. In short, you must guide your men and make them realize the importance of safety.

[1] Talk presented by Frank Rickinger, Production Manager, Hammond Lumber Co., Los Angeles, Calif., at meeting of Southern California Lumber Seasoning Assoc. November 11, 1954.

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FPRS News-Digest, Continued

NEW PRODUCTS—LITERATURE

Cut-Off Gauge

An improved model of the Snow cut-off gauge is announced by the Snow Manufacturing Co., Alhambra, Calif. The new gauge, Model 6, is made for heavy duty cutting for on-the-job contractors and lumber yards as well as cabinet shops. Made of heavy steel, it is built to resist weather conditions for inside and outside use.

The gauge is available for tables ranging from 8 to 18 inches in width. Any length up to nine feet may be set and the stop locked in position quickly, without the operator moving from his position in front of the machine. Stops are also available for multiple cutting.

Saw Tooth Shank

A saw tooth shank with improved quality and durability has been developed by Pacific Saw & Knife Co., Portland, Ore. The new "Tiger Shanks" have been introduced as a companion to "Tiger Teeth" inserted saw bits.

The processed shanks are impregnated with chromium where they support the bit and get the hardest wear. The manufacturer claims that the

"Tiger Shanks" are outperforming shanks made under former treating and plating methods and are outlasting carbon steel by four times or more.

Laminating Press Described

An air hose laminating press for fabrication of hollow core flush doors, plastic faced sink, counter and table tops, and other laminations is described in Bulletin 11–D available from The Black Brothers Co., Inc., Mendota, Ill.

The new press is recommended for bonding operations which require moderate pressure using vinyl adhesives. Operated entirely by air pressure, the press is available in regular production platen sizes from 30 x 30 inches to 54 x 120 inches, with adjustable daylight opening.

Chipper Bulletin

A chipper catalog describing a complete line of pulpwood screens for pulpwood sticks, sawmill slabs, edgings, planer trimmings, round wood or veneer cores or a combination of both, is available from the D. J. Murray Manufacturing Co., Wausau, Wis.

The 12-page booklet on Murco chippers, gives detailed specifications on various sizes of pulpwood and wastewood chippers, average production of each, with illustrations of the different type chippers in use. Copies of the booklet, "Pulpwood Chippers" (No. MC–1155–C), are available from the manufacturer.

New 59-Inch Planer

A new standard double-surfacing planer with cutting width capacity of 59 inches has been developed by Buss Machine Works, Holland, Mich. With 100 horsepower on the feed and cutterhead motors, it is said to be capable

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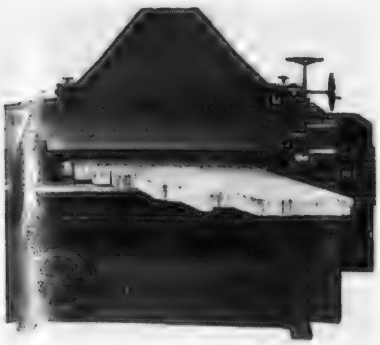

of taking cuts of 1½ inches on the upper cutterhead and 1 inch on the lower head.

This machine is reported particularly adapted to laminated roof beams and trusses as it permits feeding through complete curved structural members up to the full 59 inches. It usually eliminates the necessity of planing in partial widths and the consequent gluing-on operations.

The manufacturer points out these additional features: motor direct on arbors; complete heavy grinding rails to grind the knives in the heads; quick adjustment, one-shot lubrication system; variable feed; cast steel sectional roll and chip-breakers; and sturdy, semi-steel heavily ribbed frame.

NEW PUBLICATIONS

Chemistry of Hickory. R. L. Mitchell. Hickory Task Force Report 2. Southeastern Forest Experiment Station, Box 2570, Asheville, N. C. Discusses potential methods for chemical utilization of waste hickory wood, based on the carbohydrate fraction.

Pine Sawtimber Stumpage Prices in South Carolina, 1948–1954. J. W. Cruikshank and W. C. Anderson. Southeastern Forest Experiment Station, Asheville, N. C., Station Paper No. 57. Shows how stumpage price information can be analyzed and recommends ways of increasing the availability and improving the quality of this information.

How Much Wood in a Cord of Pine Slabs? Research Note No. 87. Southeastern Forest Experiment Station, Asheville, N. C.

Logging Slash: A Study of the Problem in Inland Empire Forests. D. S. Olson and G. R. Fahnestock. College of Forestry, Forest, Wildlife and Range Experiment Station, U. of Idaho, Moscow, Idaho.

1955 Annual Report, Division of Forestry Relations, T V A. Report No. 214–55. Tennessee Valley Authority, Norris, Tenn.

Bibliography of Wood Distillation, 1907–1953. J. D. Ross. Oregon Forest Products Laboratory, Corvallis, Ore.

FPRS News-Digest, Continued

Lateral Tests on 12 x 60 and 20 x 80-Foot Lumber-Sheathed Roof Diaphragms. J. W. Johnson. Oregon Forest Products Laboratory, Corvallis.

Oregon Maple Log and Lumber Grading. A. C. Wollin and J. R. Pfeiffer. Report G-4. Oregon Forest Products Laboratory, Corvallis.

A Laboratory Method for Testing Wood Mine Pins in Tension. W. H. Reid and C. B. Koch. Bull. 383T. West Virginia U. Agricultural Experiment Station, Morgantown, W. Va.

Preservative Treatment of Fence Posts with Toxic Oil Solutions by Cold-Soaking, Dipping, and Brushing. C. S. Walters and K. R. Peterson. Forestry Note 64. U. of Illinois Agricultural Experiment Station, Urbana, Ill.

The following publications are available without charge from the U. S. Forest Products Laboratory, Madison, Wis.

List of Publications July 1 to December 31, 1955.

List of Publications on Wood Finishing Subjects. Report 454.

List of Publications Relating to Fungus Defects in Forest Products and to Decay in Trees. Report 508.

Partial List of Government Publications of Interest to Architects, Builders, Engineers, and Retail Lumbermen. Report 1081.

List of Publications on Structural Sandwich, Plastic Laminates, and Wood-Base Aircraft Components. Report P & I–4. Lists over 250 publications on plastic, all-wood, and wood

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resin laminates, and sandwich constructions.

List of Publications on the Seasoning of Wood. Report No. 446.

List of Publications on Glue, Glued Products, and Veneer. Report 513.

Some Books About Wood. Report 399. A list of 60 books on forest resources, veneers and plywood, wood chemistry, pulp and paper, and other products and processes.

Adhesive Bonding Properties of Various Metals as Affected by Chemical and Anodizing Treatments of the Surfaces (Part A—Additional Tests on Anodized Aluminum and on Zinc–Chromate–Primed Magnesium). H. W. Eickner. Report 1842–A.

Analysis of Long Cylinders of Sandwich Construction Under Uniform External Lateral Pressure. M. E. Raville. Report 1844.

Theoretical Design of a Nailed or Bolted Joint Under Lateral Load. E. W. Kuenzi. Report D1951.

Methods of Calculating the Strength and Modulus of Elasticity of Plywood in Compression. J. A. Liska. Report 1315.

Heat Stabilized Wood (Staybwood). A. J. Stamm, H. K. Burr, and A. A. Kline. Report 1621. Presents results of tests of methods of increasing wood's dimensional stability by subjecting it to high temperatures.

Progress in the Chemistry of Lignin 1943-54. E. E. Harris. Report 2020. Surveys such subjects as distribution and nature of lignin, lignin analysis, methods of isolating lignin, structure and properties of lignin, and its utilization. Lists titles and sources of 535 articles on chemistry of lignin.

Buckling of Sandwich Cylinders of Finite Length under Uniform External Lateral Pressure. M. E. Raville. Report 1844-B. Presents theoretical analysis of the buckling of circular cylinders of structural sandwich construction. A mathematical solution to the problem, which can be applied to structural sandwich cylinders of any length and any core thickness, is also presented.

Chemical Composition of Common North American Pulpwood Barks. Ying-Pe Chang and R. L. Mitchell. Reprint from TAPPI.

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Typical automatic installation in many plants. All wood scrap is conveyed to the hog, then chips are blown to fuel bin. In some installations, chips are blown to a stoker which feeds them into boiler or furnace; in other cases chips are blown directly into fire box.
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No. E 211—Progressive Eastern hardwood distribution yard seeks recent graduate or experienced lumber salesman for sales territory in New Jersey and surrounding areas.

No. E 213—Large wood preservation company, plants throughout U. S., seeks young chemists or chemical engineers.

No. E 214—Lumber mills, headquarters Los Angeles, seek experienced supervisory and operating personnel. Consider applicants in age 40–50 bracket.

No. E 215—Large, diversified West coast forest products company, headquarters San Francisco, seeks experienced market analyst. Should have engineering, wood technology or forestry background. Excellent starting salary.

No. E 217—Midwest furniture plant seeks high grade time-study engineer. Should be forest products technologist.

No. E 218—Eastern furniture company seeks experienced lumber grader who can also buy lumber. Will be in charge of lumber shed and will determine kind and grade of lumber to go with each production order.

No. E 219—Chemist wanted with experience in the chemistry of wood and wood finishes. Salary open. Location, Pacific Northwest.

No. E 220—San Francisco sales agent of special products — lumber, particle board, pallets, seeks young men as sales trainees. (Mch)

No. E 221—Leading Midwest millwork company seeks men, age 25-35, for product design department. Prefer

mechanical engineering or chemistry background. (Mch)

No. E 222—Large southern lumber manufacturer seeks experienced young men for two positions—one leading to superintendent of production in furniture dimension plant; other, as assistant to vice-president leading to sales management. (Mch)

No. E 223—Leading Southern wood preservation organization seeks young man for research laboratory. After 1½ years research on pressure treatment of wood, he will tansfer to technical service. (Mch)

No. E 224—Southeast textile plant desires man, age 25–30, M.S. in Wood Technology or Engineering as research laboratory supervisor. Should have 2–5 years experience with glues. Excellent starting salary. (Mch)

Employment Wanted

No. 308—Forestry graduate with 6 years experience in production, development, and sales of plywood and sandwich laminates seeks position as plant manager or product development engineer. Good executive ability. (Mch)

No. 332—Young man, B.F. in forest products, B.S. in commerce, seeks position in Western lumber or plywood industry. Experienced in research and retail lumber. Age 26.

No. 333—Manager, commerce and legal degrees, age 41, 20 years experience in fine hardwoods and veneer industry as mill manager and assistant sales manager, seeks Midwest position in specific locale. Details upon request.

No. 334—Saw filer from African Gold Coast trained in United Kingdom desires additional temporary industrial trainee experience in U. S. Knowledge of grading, preservation, and classification of timber.

No. 335 — Young man, age 32, single, seeks position in furniture manufacturing. Graduate Vanderbilt University. For three years, head of own firm in wrought iron gift field.

No. 336—March, 1956 forest utilization graduate, Colorado A & M College, seeks Western position in sawmilling production or wood utilization leading to sales or purchasing. Has experience operating a Wyssen Skyline Crane. Age 24, single.

No. 337—Young man, 27, married and a veteran, seeks position in marketing and economics research. Has advanced degree from U. of Michigan, experience as research assistant in forest products, plus three years pre-engineering background.

No. 338—Wood Technologist, age 27, three years experience in research laboratory and with chemical company. Good background in lumber, veneer and particle board. West Coast. (Mch)

No. 339—Experienced lumberman, age 37, seeks supervisory position. Thorough knowledge of production costs, utilization, and sales in soft wood and hardwood mills. B.S. Forest Products. (Apr)

No. 341—Graduate, Wood Utilization, Eastern College, 1954. Former NLMA scholarship winner. Some experience furniture. Seeks research or production position. (Mch)

No. 343—June, 1956 graduate, Forest Management, Colorado A. & M. Available June 15. Prefers forestry research or management. Single. West or North. (Mch)

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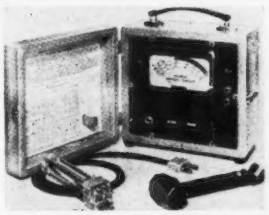

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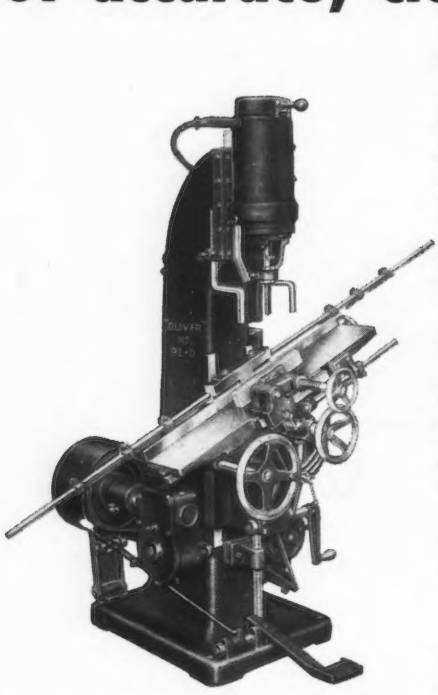

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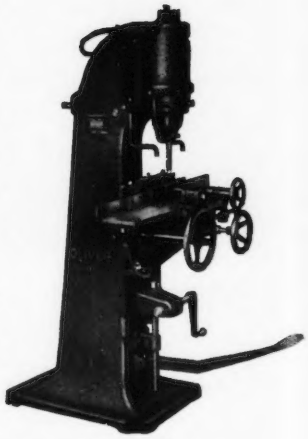

OLIVER No. 91D MORTISER

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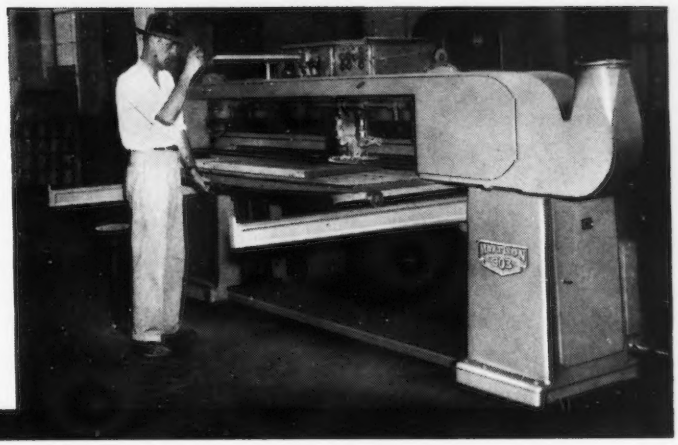

MATTISON MACHINES VITAL TO PROFITABLE PRODUCTION at United Furniture Corporation, Lexington, N. C.

United Furniture Corporation, Lexington, N. C., long ago discovered that the production of high quality furniture demands more than specification of the finest lumber available. High production, precision machinery is needed to play its part in quality manufacture.

Because of the high standards set for the furniture they make, United uses Mattison Rip Saws, Moulders, and Automatic Stroke Belt Sanders. They have found that every Mattison machine is designed and built to deliver quality work at low cost. Each machine can meet the rigid requirements established by United's production engineers.

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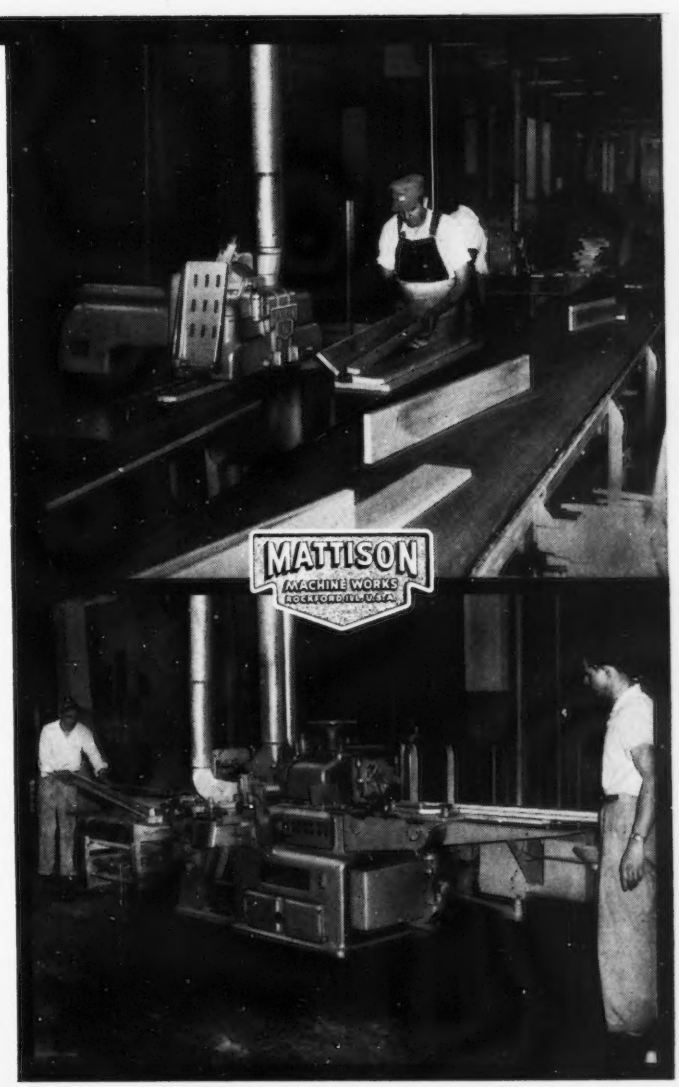

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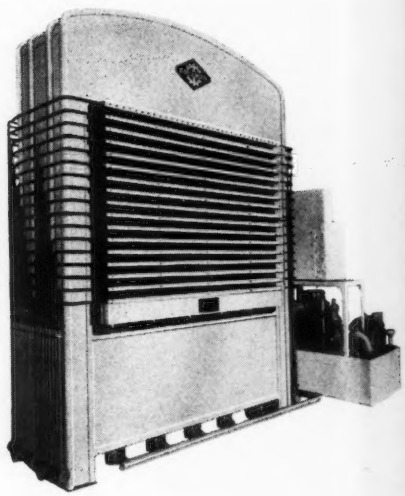

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